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THE MONIST

THE UNITY OF SCIENCE; AN OUTLINE

I. THE NEED OF A UNITY OF SCIENCE

THE idea of the unity of science is not at all new in the annals of science and philosophy. In ancient times, the Greek atomists, Democritus, Leucippus, and Epicurus advanced the idea in their atomic theory. The first experimental work which gave Chemistry a theoretical basis, that is the atomic theory advanced by John Dalton in his *System of Chemical Philosophy* in 1808, is nothing more than the fulfillment of the concept of discontinuity initiated by these Grecian philosophers. Scientific spirit which rose to such heights in the days of Aristotle, Democritus and Lucretius was suppressed for nearly fifteen centuries by political fanaticism and the reactionary attitude of the Church; but was finally revived by Descartes, Galileo, Bruno, Bacon, and the Empiricists following the Reformation. The great advance in all branches of science in the nineteenth century was in all probability due to the removal of metaphysical fungus and theological taboos which cluttered and choked the normal channels of development in the Dark Ages.

In 1865, the publication of Darwin's *Origin of Species,* containing the priceless idea of evolution, forced the religious cult to give up its last stronghold, namely, its insistence on the spiritual and hence ultra-scientific nature of life. Now that theology has abdicated its rule over science we come face to face with a wholly miraculous, unprecedented development of experimental knowledge.

UMI

A glance at any university curriculum today shows how intricately differentiated and unwieldly the whole structure has become; not unwieldly in the sense that the structure is insecure, but in the fact that it needs coördination, coöperation between the various branches, above all, unification. We have sciences in the order of complexity of their subject matter from the natural sciences; that is, physics, chemistry, geology, biology, on the one hand, to the social sciences including psychology, sociology, economics and history, on the other. Prospects of a coherent unity of such a vast body of facts are scarcely to be contemplated. Nevertheless, J. Arthur Thomson has already completed a comprehensive survey in his series on the *Outline of Science.* H. G. Wells' *Outline of History* is a parallel attempt in the field of history. Finally we have numerous philosophical rendering of unity as set forth by Spencer, Bergson and William James. There should be included in this category the work of Immanuel Kant, Karl Pearson, and more recently that of Poincaré and Norman Campbell on the metaphysical significance of science.

Before science can be unified it is necessary to put a value judgment on scientific facts, to classify discoveries according to their relative worth; in short to differentiate those things which merit scientific investigation from those which do not. The various branches of science have become enormously specialized. This specialization has always been legitimate with a purpose in view; but frequently the zeal for scientific activity is so great that data are sought on some microscopic detail which to all intents can throw no light on related phenomena. Though utility is a secondary consideration with science it must not be given up entirely.

Scientific research is an extremely laborious, often highly expensive procedure. Manifestly then, for economy of

effort alone, some criterion of value should be applied to the existing knowledge of the subject in question, and the probable benefits to be accrued from further research. But how, indeed, will it be possible to make an estimate, a value judgment of research work when each highly specialized branch in any given department of science is to all appearances unrelated to the rest? The chemist engaged in organic synthesis is not helped appreciably by the physical chemist's thermodynamic treatment of chemical processes. How then shall we fill up the gaps between the branches of one science, and the more noticeable gaps between the sciences? Is it possible, for example, to make data in plant physiology and photo-chemistry accessible for the mutual benefit of each science? Clearly each science needs a revaluation, "a making over," to be rendered available for the whole body of science; essentials must be conserved, non-essentials sifted out. Obviously a recast of the whole field is a necessary preliminary to any attempt at correlation, and hence unification. The different branches of science, once oriented with respect to each other, will have at last a common directive force or purpose in study. Witness, in this connection, the great science of biochemistry which is healing up the breach between biology and chemistry. Similar fusions are being accomplished by social psychology, physiological psychology; in particular the one great social science which is all-inclusive of sociology, ethnology, anthropology, psychology, geography, economics and history.

The purpose of this paper is to indicate the general tendencies which such a unity would assume. No science, we believe, is sufficient unto itself. Every science can not fail to be related to the totality of science; since it arose by some convenient division of labor from the parent science. Practically, however, each science has its one all-sufficient expe-

UMI

dient, namely, the cross section of reality it is investigating. Theoretically all departments of knowledge are interrelated; but frequently this unity is not needed for the matter in hand. The geologist, for instance, studies the weathering of complex granitic rocks and the deposition of their disintegration products in successive layers and strata. Obviously, any description, mathematical, physicochemical, of the history of each discrete particle or molecule of rock would be superfluous. The psychologist studies the mechanism of visual perception. It hardly seems possible that a knowledge of all chemical reactions and molecular rearrangements would in any way enhance his treatment of illusion, range of vision, etc. Hence, it is unnecessary and doubtless irrelevant for sciences whose field is of the higher order of reality, that is biology, psychology, sociology, to consider ultimate mechanisms; but in all considerations of unity these things must be taken into account. The unity or what amounts to the same thing, the causal connection of the whole body of reality is dependent on the integrity of its several parts. Progress in any department of science is typified by unity and minimization of the number of concepts under which any objective phenomena may be corraled. Wherefore a timely unification of science would do much to diminish the diversity and heterogenity of all known elements in its structure, and bring the whole system into directly intelligible relations. In physics, the Bohr-Rutherford theory of atomic structure, though inherently complex in itself, has been successful in the interpretation of such comparatively widely separated phenomena as X-ray spectra, photo-electricity and spectroscopy.

Finally, in our general system of universal causation we should find side by side with our physico-chemical and biological theories, such unique manifestations of man's activity as embodied in art, literature, history and religion.

Granted the one-ness of man with nature, as decreed by evolution, it is possible to include man's attributes, even his philosophies in our general system of universal causation? Or are these things beyond the domain of science, extra-scientific data? The influence of psychology in this as well as other questions is predominant. Thus we know that all manifestations peculiar to life, organic species, man in particular are not independent of physical structure. Objections to a universal rationale of the world and activity have been usually assigned to the alleged stand of the human spirit against any all-inclusive world systems. These and other questions will be discussed at length in the discussion to follow.

II. Plan and Scope of the Unity of Science

Syntheses of all fields of scientific inquiry have been contemplated, as noted above, by some of the ablest scientists and philosophers. Such popular works as Haeckle's *Riddle of the Universe*, and even Burrough's *Accepting the Universe*, suffice to show how current is the idea that physico-chemical laws are not inseparable from life phenomena as exemplified by the biology of low organic forms on the one hand, and the sociology and psychology of human activity on the other. No strict "Unity of Science" would perceive any rigid line of demarcation between organic species and man, but such contrast is valuable in showing the range and universal applicability of physico-chemical laws.

A brief survey of the natural sciences is preliminary to philosophical deductions therefrom. I shall attempt to pass in review a few of the cardinal notions embodied in modern physics, chemistry, biology, psychology, and sociology. Any authoritative treatment of science in general

UMI

could hardly fall short of a rehearsal of all evidence and proof brought forth by the science itself. In this report nothing more than the broadest outlines and most general concepts will be presented.

Herbert Spencer, the nineteenth century evolutionist, was the first to recognize the apparent gradation of the sciences; for each science following physics is concerned with a higher order of reality. The sciences aforementioned are in the order of their increasing complexity, hence there are no rigid boundaries between them. On the assumption, first, that the advance in philosophy and allied fields is in direct ratio to the known and directly workable achievements in science, second; that matter, the stuff of reality, is certainly the foundation on which the whole structure has arisen, I shall endeavor to show just how the modern view can not fail to necessitate a reconstruction of old religions and philosophies.

Research methods today do not halt unless they are forced to intermediate stands in their inquiry to seek diligently to reveal every link in the causal chain. Social science is not satisfied with the precept that the proper study of man is man exclusively, but strives to show just how man's actions are related to his environment and his inheritance, both of which are physico-chemical and biological problems. The fact that man is a part of nature does not detract in the least from his heights of achievement in the arts and literature, but enhances him so much the more for the miraculous development which this day may carry with it potency of faculties hitherto unknown.

Further, the great advance of man throughout vistas of geological time has certainly not been independent of the matter subject to physico-chemical laws, for man is an incarnation, that is a form of matter, as is also a crystal of mathematical symetry and the humblest self-sustaining

organism, the amoeba. How matter could contain within it the potentiality of life and what is even greater, the historical evolution which has culminated in the human race stands out by far as the supreme problem which confronts the world of science. To science alone belongs the solution of this problem, and when I speak of science I do not mean science in the orthodox sense, that is to say the physico-chemical and biological sciences, but also the social and philosophical science. A tentative solution of this problem will be advanced later.

All investigation is scientific which starts out with the assumption that the observer is in direct relation to the reality which confronts him. All else, certain forms of physical research and mysticism, abandons at the outset this claim, for it decrees that its relation to the unknown can not be had on direct terms, but is conditioned by immediate intuition or some other equally questionable principle. If the results of psychical research are valid they need a reorganization in terms of workable realities. Whether such data are phases of abnormal psychology or not, is, it seems, an open question. In general, science works only when there is a connection between two phenomena in nature which may be directly verified directly by experiment. That this connection should exist is evidently the sole pre-condition for advance in science. The coördination of a series of related phenomena is scientific description. Belief that the coördination exists is theory or working hypothesis; verification of the coördination is scientific law. The fact that this relation exists between a series of phenomena, and could not be otherwise is the foundation of the deterministic cult and atomistic fatalism in philosophy. These relations will be more apparent after the systematic treatment of the several divisions of science.

III. Physico-chemical Indications of Unity

To physics has always been accorded phenomena of statics and dynamics directly observed in material systems; for the method of this science is always inductive, that is, to formulate laws from experimental data. These laws, if they describe relatively simple phenomena, are usually summarized by mathematical formulae. When any given configuration of a material system is a function of several variables the mathematical description becomes exceedingly complex, and fails to give an adequate picture of the physical event in question. The fact that phenomena of mechanics, molecular physics, electricity, sound and light can usually be expressed by formulae indicates that these properties of matter belong to a simple order of reality, a low form of evolution. Chemistry is partially successful in mathematical interpretation of experimental data, but biology rarely attempts such an interpretation. Nevertheless, some men of science firmly believe that all phenomena in nature, animate and inanimate, can be anticipated by a series of differential equations with the three spatial variables, "x," "y," "z," and the time variable "t." Thus, if we knew the differential equations whose variables expressed the relations between physical environment and biological inheritance we could predict the mode of response of any organism whatever to any possible situation. Such a view is strict determinism.

In the history of physical science those laws first formulated we may call "gross laws of nature" for they summarized simple laws of motion and energy directly perceived by our senses. These are the laws of statics and dynamics, the Newtonian mechanics. The latter-day physics has, on the other hand, been forced to forego this gross

sensual induction of laws and has been forced to consider in her calculations quantities forever inaccessible to the human eye. Atomic theory was the inevitable interpretation of the fact that elements combine to form compounds in simple proportions by weight. Prior to 1896 the atom was regarded as the "ultimate building block" in matter. Now the idea that matter is built up of rigid spheres has been supplanted by the view that the atom is a planetary system of central nucleus and electrons, a structure of almost inconceivable magnitudes. The old atomic theory was quite successful in explaining atomic, that is to say, chemical phenomena, but manifestly unsuited for the interpretation of the subatomic phenomena of radioactivity, X-rays and crystal structure. Matter, then, so far from being hard and continuous, possesses a tenuous, "bird-cage" structure.

Modern physical science goes further to say that all atomic species, some eight-seven in number, are built up of hydrogen nuclei, positively charged, and electrons, negatively charged. The space occupied by these material constants, protons and electrons, is negligible in comparison to the distances between these particles. Hence, matter which appears en bloc so homogeneous is in reality highly discontinuous in its structure. Such varied phenomena as radio-activity, spectroscopy, thermionic emission, and photo-electricity independently confirm this picture of atomic structure. Since this theory harmonizes with the facts, we may conclude that matter does actually possess this infinitesimal structure, and that matter therefore, so far from being in a quiescant state is in a state of turmoil and perpetual flux. The idea that the universe in which we live is an infinitesimal part of some vaster universe is not to be scorned; for likewise a collection of atoms would be viewed as a universe by inhabitants of sub-atomic worlds.

Chemistry, too, like physics, was at first largely descriptive. The early developments of the science followed directly from laws deduced from an extensive study of compounds and chemical interactions of matter. Theoretical or physical chemistry was a later development of the science. It is to this branch of chemistry we owe the systematization and organization of the manifold diversity of chemical phenomena. The ionic theory of electrolytic dissociation, the kinetic theory of gases, the thermodynamic treatment of chemical processes have all been invaluable in reducing a mass of apparently unconnected data to a few intelligible laws. The amazing development in physical chemistry incidental to the discovery of the electron in 1896 has succeeded in reducing chemical phenomena to a more unitary basis than ever before. The electron theory of matter has given men of science an interpretation of chemical affinity, combination and interaction unparalleled in the history of science. Thus the simple thesis *Electricity is Matter,* has been fruitful in explaining many of the phenomena in heat, molecular physics, electricity, light, sound, radio-activity, and such specific chemical processes as ionization, oxidation and reduction and chemical combination.

Electricity was first thought an imponderable elemental principle which imparted novel properties to a substance without changing its intrinsic nature (B. Franklin's *One Fluid Theory*). According to the fundamental idea in modern electron theory, namely that electricity is inherent in matter, it is easy to see that manifestation of this force is conditioned by the disturbance of the electrical stability or neutrality of matter. Ultimate particles of electricity have been weighed, their charge and size measured. Thus matter and electricity itself are atomistic, granular in their structure. Moreover, recent work of Millikan, Nernst, Einstein and Planck supports the idea that energy too is

atomic. Planck's radiation theory states that energy is discontinuous; any given amount is a multiple of the quantum of energy "h," the Planck constant. Evidently the New Physics has demonstrated objectively (though we shall probably never be able to verify by our senses the reality of molecules, atoms, or electrons), that matter, electricity, and energy are discontinuous; that these entities possess an exceedingly fine structure. There is no a priori objection in assuming that matter is infinitely discontinuous.[1] Indeed this hypothesis has been tacitly assumed by modern workers in atomic structure. Radio-activity, X-rays, thermionic emission, photo-electricity demand a sub-atomic theory of atomic structure. If in the course of future research results are obtained which cannot be explained on this basis it is highly probable that sub-electronic theories will be developed. Millikan[2] has insisted that the electronic constant "e," that is, the lowest common multiple of any electric charge, is not a "statistical mean." He further assures us that no evidence has yet appeared for sub-electrons. There is no objection on purely logical grounds against the tendency of the intellect to subdivide matter as well as time and space "ad infinitum." But in modern science a convenient stopping place is the electron since its validity is conditioned by empirical methods, whereas the laboratory technique necessary for the verification of sub-electrons (if they do exist) has not yet reached a high enough degree of precision. It is not improbable, therefore, that present theories of atomic structure are but condensed summaries of experimental results obtained. Complexity of theory is in direct ratio to the finesse of experimental technique.

Electron theory has not only been applied with great success to physics but has also given a plausible explanation

[1] Perrin, *Les Atomes* (1920).
[2] Millikan, *The Electron* (1916).

of the interrelations of structure of the eighty-odd elements, a specific chemical problem. This theory has been the unifying force "par excellence" in physics and chemistry. In particular, the "hydrogen-helium" theory of atomic structure advanced in 1916 by Harkins and Wilson shows that the numerical regularity in atomic weight of the elements is to be accounted for by the fact that the atoms differ in structure only as regards the magnitude of the nuclear charge and the number and arrangement of the negatively charged electrons. We may write the formula of helium p_4e_4 and calcium $p_{40}e_{40}$ where p is the symbol for proton and e for electron. Protons and electrons are the ultimate material entities, so far as now known, experimentally.

All physical and chemical properties are believed to be due to the number and arrangement of constituent protons and electrons. As a matter of fact the precise arrangement of electrons in the more complex atoms has not yet been worked out; mathematically the problem is exceedingly complex. We do know that the atoms simulates in general a solar system consisting of protons with which the bulk of the weight of the atom is concentrated and secondly planetary electrons circulating the central nucleus with speeds which approach the velocity of light. If we accept this idea it is possible to explain chemical reactions (the ultimate cause of which has puzzled chemists since the beginnings of the science) by the loss and gain of electrons in the valence or outer ring of electrons. Valence electrons would be most easily detached in the impacts between atoms and are therefore active in nearly all chemical phenomena. Any given configuration of electrons in the outer ring is manifestly the position of maximum stability, and depends of course on the orientation of intra-atomic electrons.

Details of the electron theory of chemical combination have been worked out by Lewis and Langmuir in their

Octet Theory of Valence.[3] Chemical affinity is then electrical in nature and depends, as has been adduced, on the number and arrangements of the valence electrons. This is indeed the case, and until contrary evidence is brought forth, we may say that every chemical change in nature must depend ultimately on the interchange or binding of electrons. Perhaps in organic chemistry this generalization is too broad; since molecular and not electronic attractions may result in chemical reaction. It seems certain, however, that all directive forces are electrical in character. Whence we may postulate the identity between electrical attraction and chemical change as the fundamental starting point in the new science of chemistry. The Lewis-Langmuir theory has introduced in the field of chemistry a single concept, namely the application of electron theory to chemical change which is inclusive of all known combinations and interactions of matter. This theory has played an important rôle in the unification of science.

Another unifying force in science is thermodynamics. Thermodynamic treatment of physico-chemical phenomena is based on two concepts, the first and second laws of thermodynamics. As far as the theory has been extended it has been proved that all known phenomena in physics and chemistry conform to formulae which can be deduced from these laws of thermodynamics. The validity of the two fundamental laws is not conditioned by any theory concerning the atomic structure of matter.

Experience leads to the belief that all energy transformation obey the first law of thermodynamics, that is, the law of conservation of energy. The second law is an elaboration, a limitation of the first; that is to say, this law is a generalization from experience that the conversion of heat into mechanical work is not limited. Production of

[3] F. H. Loring, *Atomic Theories.*

work through heat can never exceed a theoretical amount which is a function of the temperature gradient between a system of high and a system of low potential energy. When any mechanical system or arrangement of matter produces work it suffers a loss of "free energy," a permanent loss in the potentiality for doing work. All energy changes in an isolated system whether manifested by heat, mechanical, chemical or electromagnetic changes such as electricity, sound or light produce a permanent energy loss in the reacting system. All inorganic happenings in nature take place in such a way that maximum equilibrium adjustment is obtained.

A study of chemical reactions can be approached from the thermodynamic as well as the electronic point of view. Thermodynamical treatment has been fruitful in deducing the general tendencies of matter. In general, no chemical reaction will take place without a decrease in free energy or an increase in the entropy of the system. This means that natural forces are eternally striving for equilibrium; for when equilibrium is attained no chemical change will take place.

Evidently the second law of thermodynamics is a summary of inaminate nature. It may be expressed in various ways. (1) Every physical or chemical change taking place in a system causes a diminution of the work content of the system. (2) The entropy of the universe tends towards a maximum. Now entropy, the ratio (Q/T) is a measure of the heat content of the surroundings. Heat, according to kinetic theory, is a function of the kinetic energy of the molecules. When the entropy of the universe attains a maximum no physico-chemical phenomena will be possible because no potential gradient will exist between the surroundings and the system which formerly could produce work by virtue of this inequality of potential.

The total energy is the same, however (Law of Conservation of Energy) but has become unavailable for producing work. The presence of unavailable energy in this universe or any other signifies that energy has not attained its maximum value and incurs thereby physical and chemical forces which in their surging to equilibrium produce manifestations which modern science is attempting to describe.

This universal tendency of different species of matter to interact in the direction in which heat is liberated, or in which potential energy is transformed into kinetic energy is nature itself. This perpetual mustering of natural forces to equilibrium is the cause of all movement in nature. Every natural event which has taken place in the evolution of the solar system is nothing more than an expression of this everlasting surge to equilibrium. On our own planet diastrophism, vulcanism, gradation; in short geological change of every description are all phases of the omniscient driving force to equilibrium. The chance that any universe exists in which entropy has not attained its maximum is inconceivably minute.[4] According to the second law of thermodynamics the universe had a finite beginning in time however remote, for in an infinite time maximum entropy would be reached and no physico-chemical change would be possible. Life, we shall see presently, is a mechanism, a unique principle, which temporarily retards the increase of entropy. The chance that it exists anywhere in the universe is an infinitesimal of the second degree.[5]

IV. Biological Indications of Unity

The test of any unity of science is its ability to coördinate biological phenomena with physico-chemical mechanism. The fundamental working hypothesis in this respect is that

[4] James Johnstone, *Mechanism of Life* (1921), Ch. 11.
[5] Ibid., p. 209.

unity does actually exist; that as we are bound to recognize in biology a set of phenomena of a higher order of complexity, it seems certain that this complexity of life phenomena does not arise *"de nova"* by a separate act of creation, but that it arises by infinitesimal gradations out of purely physico-chemical interactions. Let us consider the criteria of life; movement, metabolism, irratibility, reproduction. These functions are said to differentiate living from the non-living. Now all these categories of life will on closer examination bear analogy to physico-chemical processes in vitro. It is just their integration we call life. Metabolism is from the point of view of kanabolism the oxidation of carbohydrate, fat and protein to carbon dioxide, water and urea, and coexistent with this transformation the setting free of heat and mechanical work. Movement of an organism is nothing more than the explosive decomposition of these highly articulate carbohydrates, fats and proteins. Life is said to be due to the building-up and tearing-down of proteins.

Biochemistry, the science concerned with these matters, was made possible when all hypotheses of vitalism, mysterious life forces and entelechies were banished out of its domain. Vitalism is nihilism in science. It advocates a negative attitude, a laissez-faire policy. Little advance was made in practical biology when vitalism was the hypothesis in vogue. The pace was set when Wöhler in 1828 showed that an animal product, urea, could be obtained by the molecular rearrangement of an inorganic substance, ammonium cyanate. Freedom of organic chemistry from the hypothesis of a vital force prepared the way for the manufacture of a host of organic substances of exceedingly complicated structure and hence novel properties. The work of Emil Fischer and contemporaries in the field of carbohydrates and proteins makes it seem prob-

able that starches and even proteins will be synthesized by the chemist. Apparently life in its low forms at least presents no baffling problems to the biologist today.

The most important characteristic which differentiates living from the non-living is the ability of life to conserve energy, to arrest through sheer organization of matter the universal trend of natural forces to equilibrium. Thus cholorphyll, the green coloring matter in plants, absorbs radiant energy from the sun in converting substances of high energy content, namely sugars, fats and proteins. This is a true conservation of energy. Radiant energy or heat energy is an attribute of kinetic energy of the molecules, and is therefore unavailable for doing work. Life in all its manifestations is a mechanism which transforms this unavailable kinetic energy into potential energy capable of doing work. Otherwise stated, life retards the increase of entropy by converting systems of low energy content into aggregations of high chemical energy. Mechanical and heat energy liberated by the metabolism of these high energy compounds (carbohydrates, fats and proteins) enable the plant or animal to initiate movement which in all its diverse phases is nothing more than the adaptable interaction of the organism with its environment. The resultant mobility afforded by slow processes of accretion of high energy compounds makes possible specialization of function and hence the manifold diversity of species.

Thus it seems certain that the whole history of any particular organism is strife against the equilibrium which control the course of phenomena in physics and chemistry. But while life has to conform and adapt itself to its physical and chemical environment and obey the laws of the matter which is the sum and substance of its structure, life must, on the other hand, perpetually strive against the equilibrium sought by natural forces. And always the physical

UMI

forces win out; for at death organic tissue degenerates into simpler substances. According to the mechanistic hypothesis the elementary life which first appeared on the globe contained within it the promise of such diverse and spectacular development only in the sense that evolution was inevitable and determinate. Evolution, this apparent uphill activity in matter, this push from the simple to the complex, has been designated by Henri Bergson as the "elan vital," the vital impetus, but such an assumption of a vital force is gratuitous, if the treatment to follow is at all valid.

In the first place, a unity of science could scarcely be possible except on mechanism which is in essence the genetic relationships of all departments of science (biology, sociology, and psychology) with physics and chemistry. If this is not so, if mechanism is inadequate, we must either assume or postulate a specific "life" force to account for biological phenomena of lower organic forms, and in addition to this "life" force a "spirit" principle to account for human attributes. There is no alternative; we must choose either one or the other of these interpretations or else arrive at an "impasse" in our knowledge. Indeed, a supposition of a "life" or "spirit" principle is in essence equivalent to the "impasse," for such an assumption closes the door to investigation.

Modern science is itself a sufficiently imposing answer to the worth of ambiguous vital forces. When we consider the fact that all achievements of modern science are independent of vitalism we have the most convincing evidence that mechanism is the ultimate explanation, the "grand show-down." All evidence points to the conclusion that the inorganic, inanimate, shades off by scarcely noticeable gradations into the organic, and the organic evolves by degrees into more complex forms and species culminating finally in man. Hence the argument for mechanism seems

pretty sure, for biologists have much evidence to support the hypothesis that life can be generated directly from matter, given certain conditions of temperature and pressure and the right type of colloidal solution.

Organic generation of the primary life elements is, then, nothing more than the condensation or aggregation of matter resulting in a structure of constituent high potential atoms and molecules which by dint of their arrangement and mobility make possible an adaptable interaction of these life elements with their environment. It is more difficult to explain the evolution of life, but if we take into consideration the fact that continual flux of the external physical environment necessitates variation and mutation of the organism for its survival we have a fairly plausible, all-inclusive (because it takes account of all possible factors) explanation of how evolution came about. These mutations are transmitted, and if favorable result in modification of the original type and eventually new organic species.

However spontaneous organic evolution may appear at first sight, it seems undoubtedly true that every mutation, however slight, is pre-determined by the structure of the organism and characteristics of the environment. If we take into consideration the fact that evolution is a process that has been going on for millions of years it seems highly probable that its results can be explained on this basis. We must recognize the principle of "retardation of entropy increase" as the fundamental principle upon which life phenomena depend, for the apparent conflict between physical forces tending to maximum entropy on the one hand, and the organizing, conserving tendency of life on the other, makes evolution possible.

V. Psychological and Sociological Indications of Unity

Social science is the attempt to describe human characteristics in terms of organic structure and physical environment. It is highly probable that the evolution of the higher animals and finally man from unicellular organisms is infinitely more dramatic than the initial formation of the first life forms from highly sensitized molecules, though some naturalists are disposed to believe that once granted the synthesis of the organic from the inorganic the subsequent evolution follows as a matter of course. Be this as it may, many chemists have come of late to believe that certain substances prepared artificially do actually possess a behavior as interesting and withal as sensitive as the lower forms of life. It is just this bare fact of evolution from homogeneous to heterogeneous that is the central fact in nature, and whether it is possible to explain it in all its diverse phases by any general principle as "retardation of entropy increase" remains to be seen.

Apparently the gap between elementary biology to the study of man as exemplified by psychology and sociology is far greater than the gap between biology and physico-chemical laws. Correlation of biology, physics and chemistry with psychology and sociology is predicted by the unity of science. The basic idea of unification may be accepted as fact; further research is simply a plan of coördination, a vindication of the idea of unity.

In psychology and sociology we are dealing with phenomena immensely more complicated because the material structure is more complex. Nevertheless basic laws of stimulous and response, that is, the interaction of the

organism with itself and the environment are employed with advantage to the human organism. In social science we can make no simple generalization as we did for matter, namely its tendency to equilibrium, for the factors and variables as stated above are immensely more complex. However in this study of man we occasionally get glimpses of the underlying causal connection between the different reactions and social phenomena exhibited in the life of man. If the world is at heart a unity, if man himself is the goal of the evolutionary process, rationalization of human phenomena in the light of bio-physical science is inevitable. The unity of science shall decree the one-ness of psychology, sociology, philosophy with biology and physico-chemical laws. This working hpothesis makes possible the science of man. No attempt will be made in this report to present an exhaustive argument for the interrelation of human qualities with physical structure, but simply to sound the dominant note, the general tendencies apparent in this field of inquiry. The dependence of higher manifestations of the human being such as emotion, reason, memory, will, on specialized chemical structure is the fundamental axiom of the treatment to follow. In point of fact, biochemists have brought forth much evidence to support the belief that certain traits and mental characteristics depend on the functions of the ductless glands, the pituitary, thyroid, and adrenal glands.

The intimacy of association of the human organism with its heredity and environment is a cardinal fact in social science. Recognition of this association has made possible the science of psycho-analysis. Philosophers have already been partially successful in interpreting human behavior in the light of one self-sufficing concept. Schopenhauer's *Will to Live*, Freud's doctrine of the wish are cases in point, but such generalizations appear too narrow. Other

factors may enter in to modify one's interpretation but it is not improbable that in the long run the causal nexus will be weaved for all our actions in the world. Indeed the claim of free will is but an expedient of the individual. What appears to be indetermination, freedom, is nothing more than an attribute of complexity of organic structure and its manifold possibilities of response. An individual's choices of response to a single situation are usually so numerous that he imagines he has free choice in the matter, but finally he chooses that reaction which secures the greatest adaptation to all factors entering into the situation. Moral decisions on this view are merely a property of orientation of the cortical cells in the brain. Now what bearing has all this on electrons and theory of matter? Simply this: the same inevitableness and determinism which applies to the inorganic world is also applicable here. For lower forms of life this has been duly summarized by Darwin in his law of survival of the fittest. In man, coöperation has been substituted to a large extent for struggle. And why? Simply because coöperation and the morality it implies, has in civilization a survival value. Does the fact that morality has a biological value in nature call for unnatural or rather supernatural force mediting through nature? Do qualities, essentially human, love, hate, imagination, reason and will evoke the necessity of a spiritual principle in nature? Probably not. And appropos of the fact that these qualities have their seat in matter, the physiologist has already traced their origin to specific organs of the body. A counterpart and parallel of these physiological reactions are the molecular rearrangements within organs themselves; and these molecular reactions, as we have seen in the remarks on chemistry are coexistent with electronic changes within the molecular.

Consider for example the process of thought. This faculty has been localized in the associatory tract of the brain by psychologists. Various theories of consciousness have been advanced to account for thought processes. Thus far it has not been proved that no part of the physical energy of the individual assimilated as food has been transferred to an equivalent amount of psychical energy of the brain cells. Some theorists regard consciousness as a sort of luminescent (for want of a better word) activity of the brain cells. In any event the ultimate solution of the problem of consciousness, if scientific, will be in physical terms. If chemical reactions occurring in the brain are concommitant with thought processes as most investigators believe, it is but a short step to say that they are the thought processes. Unfortunately a great deal of confusion exists in the literature concerning the philosophical breach of conceiving consciousness as a physical thing. Experimental technique, it is claimed, can never measure the awareness or sense of identity which most psychologists are prone to assign to the function of consciousness. However, it is not inconceivable that the ultimate particles of matter, protons and electrons, have psychical as well as physical properties. Such an idea is manifestly a postulate; and so far from solving the problem simply postpones its solution. The view that matter has a psychical as well as a physical component is a resumption of the old philosophical doctrine of Hylozoism which is in essence the endowment of mind in lower natural forms to explain its presence in the higher.

Summarizing, we may lay down the general axiom that physical changes and hence changes amenable to the experimental technique of physics and chemistry take place in every case parallel to higher manifestations of activity in the human being such as emotion, reason and memory. This is a restatement of Weber-Fechner's law of psycho-physical

parallelism. Personality, the quality which enables us most readily to differentiate human types, is simply the resultant of inherited structure and the modification of this structure by various external influences of which environment as expressed by education and religion, at present, play a major part. Response of the individual to any item in his environment is a resultant of his past experiences and their expeditious correlation to the matter in hand. In philosophy this view might with propriety be called determinism or atomistic fatalism since it rules out the intervention of any principle foreign to natural law. It is all inclusive for the simple reason that it makes all phenomena of nature nature itself. Hence, we have eradicated by this philosophy all traces of the dualism of matter and spirit for matter and spirit are one and the same. This is the general conclusion of "Monism" which endeavors to coördinate all phenomena whether known or unknown.

Social and economic generalities such as law of supply and demand, Maltus' law for increase of population; individual generalities such as Freud's *Wish* and Schopenhauer's *World as Will* and Idea, cited above are all indicative of that determinism which pervades the world of individuals and society at large as well as the chemical world of molecules, atoms, protons and electrons.

Physical concepts of potential difference, gravitational potential, conversion of potential into kinetic energy are analagous to phenomena in our social world. In economics what indeed is there to prevent us from saying that a fall in the price of wheat is due to a fall in the potential between the supply and demand for that commodity? Is not this law of supply and demand as rigid in its operation as the law of gravitation? It is not perhaps correct to say that laws are rigid or inevitable in this sense, for laws are, we must remember, descriptions of certain processes which are

bound to recur in the same way under the same conditions.

Physical terminology may also be applied to the individual. Individual traits have been demonstrated by sociologists to be a function, not of himself alone but also his surroundings, his interaction with the world of persons and things. A man reared in isolation has few of the qualities of a social being. In chemical terminology his affinities, his valencies for possible combinations and relations with his environment have not been saturated. In chemistry we have seen that it is just this fact of combination of atoms into compounds that alters their properties. Furthermore it is not so much the mere building up that is important in chemical synthesis as is the arrangement of constituent atoms within the molecule. So also when we consider a human being we find that in addition to his biological inheritance, determinable and unalterable as it is, there are in addition the possibilities of social combination and modification of the original type.

The four wishes,[6] namely, desire for new experience, desire for security, desire for recognition and desire for response have already been diagnosed as the four fundamental affinities of every normal person. Each one of these four wishes can be segregated, analyzed, and its basic nature traced to the physical structure of the organism. Take "security" for example. This wish is nothing more than craving for self-preservation inherent in the structure of every living thing. This wish is an expression of life's stubborn stand against impartial natural forces. Since this tendency is universal in life, is the main criterion by which we identify life, it is perhaps correct to say that life too is impersonal. Life's demand for its own preservation and perpetuation, far from being a different principle, is identical with the deter-

[6] Park and Burgess, *Introd. to Sociol.*, p. 489.

minism demanded by natural forces for their fulfillment, with this one difference; namely, that while natural forces everlastingly seek stability and a sort of dynamic equilibrium in which the tendency for a given type of matter to dissociate is balanced by the reverse tendency of the products of the dissociation to combine, life, on the other hand, maintains its organization and prolongation by instability, unsaturated compounds and perpetual disharmony with the environment. Life must always strive for adjustment with the environment and once this is achieved, life must do one of two things, depending on whether it values adaptation with the environment as its end, or whether on the verge of this complete adaptation it changes its goal and makes sallies in other fields of endeavor. This latter course makes for advance and in the long run for self-preservation of the species.

Life, as a force in nature, paid for its mutability and versatility with the price of everlasting turmoil and maladjustment to the surroundings. Evolution abounds with illustrations of the worth of this law of life. Species, such as the Paleozoic trilobites, Mesozoic reptiles and many Cenezoic mammals who by inordinate specialization sought their own comfort and self-satisfaction in the environment were doomed to destruction, for when the physical environment changed by a greater increment than their self-sufficiency had provided for they were blotted off the earth, and the sedimentary rocks formed in those times alone furnish a record of their sad démise.

This law of life, namely, variability and perpetual strife for (and at the same time against) a too complete adaptation to the environment is applicable not only in the narrow sense to the purely physical type of adaptation (as evinced by structure of physical organs, e. g., lungs influenced by oxygen content of the air) but also to mental and social

adaptation. Thus, if the race evolves for its comfort a smug, cozy, sugar-coated philosophy or religion, it will stifle advance in these fields. Since the individual's own mental and social environment are simply arbitrary provinces of his one all inclusive environment, it is clear that too great an adaptation in any one field will be paid for by the price of mal-adjustment of the organism to his whole world.

Pending further research in biology on the nature of life it shall be legitimate for men of science to assume as a working hypothesis that the so-called spiritual attributes of man, i. e., his innate tendencies in action, thought and will, are objective phenomena subject to observation and proof on purely physico-chemical grounds. The other belief, now widely current, is that aforementioned human qualities are forever beyond the scope of physical research and belong to the machinations of some supernatural force. Thus the theory of psycho-parallelism is adjudged to be the only solution to this problem of "matter and mind" by many philosophers and theologians, but such invocation of dualism amounting to the assumption of a "spirit principle," deity, or some other nameless "X" really amounts to confession that the problem is insoluble.

VI. Philosophy of the Unity of Science

Belief that a unity of science exists is really the foundation of the scientific development of the idea. Intuition of the unity or one-ness of phenomena first definitely expressed by the Greek atomists is itself a scientific working hypothesis. Modern experimental work is ample vindication of the idea of unity. The central idea in Kant's phil-

osophy, namely that "God, Freedom, and Immortality" demand the presence of a changeless, abiding reality behind the ever-changing phenomena or appearances of the sensual world, has been assimilated by Christianity and other divine cults. Such concepts may afford comfort to "tender-minded" people who in some way visualize the all-sufficient nature as a principle inimical to their fondest hopes. Psychologists, notably J. H. Robinson, recognize the fact that adaptation of thought to a preconceived idea is fruitful of a certain type of strengthening of the idea; in other words, the idea adapts, and this is the significant point, all phenomena both natural and so-called supernatural in conformity with the desired concept. Witness in this connection evolutionary concepts devised to strengthen rather than undermine its fundamental dogma. In contrast to this method of thought is the open-minded critical method which has been alone productive of advance in the welfare of the world, a welfare evaluated by better adaptation of man to the environment in which he finds himself. This environment is not only physical but is also social and personal and more often a combination of the three.

Thus far we have discussed the relationship of science to nature but have barely mentioned its relation to religion. This relation is incidental for we find that religious experience is sublimated and takes on quite a different character when made one with the scientific facts.

In the evolution of the race, awe and fear in the presence of natural forces were counteracted to a certain extent by the manufacture of deities whose anger could be appeased to a certain extent by offerings and propitiation. Polytheistic religions flourished because no apparent connection could be traced between different natural phenomena such as wind, fire, sun, moon, etc.; but when this unity was perceived one personal God was invented to console

misfortunes and tribulations of a suffering humanity. The problem of evil became a central one in the theology of the day. This necessitated the creation of a devil or negative principle to explain the anomaly that rain falls on the just as well as the unjust. Personal immortality offered consolation to those whose wishes could not be fulfilled in this life. Indeed, the "everlasting peace" sought would be a negation of life itself for life as we have seen depends on the fight of the living against equilibrium tendencies characteristic of natural, physical forces. Humanity recognizing these things, thanks to the advance in science, has turned from speculations of future life to betterment of this life. Maximum utilization of natural resources and the "greatest happiness of the greatest number" shall be watchwords of the new era. The race once it is conscious of the fact that it is but an evanescent episode in the history of a planet doomed to destruction will coöperate more efficiently than ever before for the mutual good. In the last analysis it is application of physics and chemistry that has transformed the world and it is to physics and chemistry that civilization will be indebted for its new philosophy.

Religion and science, however different in method, have the same underlying motiff in rationalizing and trying to make intelligible the sum-total of world phenomena. There is really no qualitative difference between religious monists on the one hand who seek to reduce the world to a unitary view, that is, the supremacy of deity in creation and altering the course of natural events, and on the other hand, scientists who strive to explain the sum-total of reality by movements of atoms and the interrelations of matter, energy and force. While one asserts supremacy of the sentimental, the other upholds vindication of the rational. The fundamental purpose in such diverse interpretations is to seek order and unity amidst the plurality of events and

things. Religious interpretation is usually based on feeling and sentiment and thereby claims transcendency over the mundane considerations of science; but science is ever ready to abandon previous views. The way of adventure and life is indeed with science for the very uncertainty that science makes for its devotees (especially in point of ready abandonment of old theories) is a condition of their life. Religion offers a less enticing goal for its followers. The paradise and complete repose in the bosom of an infinite being is Budda's *Nirvana,* surely, for their all man's doings, good and bad alike would be dissolved in the Absolute, the Infinite All. This is denial of life surely for the very form and stuff of life is Dialectic. Deprive life of that indispensible element and you no longer have life.

Summing up, we may say that matter, according to the New Physics, can be resolved into protons and electrons. And since matter is the vehicle of all known phenomena, inorganic and organic, the ultimate properties of our two ultimate entities, protons and electrons, are of prime importance in the construction of our philosophy. Mass, charge, and velocity, characteristic of the electron by itself are quite insufficient in deducing the qualitative heterogenity of all known appearances in nature. New properties arise by combination and association of these nuclei and electrons, and it is in just this fact of combination that we derive our philosophy.

Laws of probability tell us that atoms left to themselves to collide at random will not in an infinite time take on a form or configuration apparent in any natural object. Attraction between positive and negative has always been postulated or implicitly assumed by physicists. It is doubtful that the nature of this attraction can ever be explained. It seems that this attraction is purposive or teleological to use the language of the Greek philosophers, because it holds

the ultimate entities together and makes possible the whole drama of evolution.

In conclusion (and that phrase is inadequate for it implies that an end, a definite, final tendency of the universal creative energy has been apprehended), it seems legitimate to say that "mechanistic teleology" describes all that mankind knows regarding nature and her mode of operation; mechanistic, in that she uses physico-chemical laws functioning through the matter which is the substance and substratum of all her manifestations, teleological, because she works purposely towards an ideal or goal which enlarges and takes on quite a different character once it is reached. Nature, as she has manifested herself in life phenomena annuls, and at the same time, confirms, the efficacy of her natural processes.

Persuance of the method of inquiry outlined in this report will finally reveal, (1) whether physico-chemical formulation is adequate to explain all manifestations in the total range from the lowest to highest expressions of the evolutionary force; (2) whether or not these expressions are separated, discontinuous, and have no genetic connection with physico-chemical systems, and hence by their very nature are removed from a mechanistic interpretation. Evidence for the latter view will be founded not by dogmatic assertion that the physical and chemical sciences are forever unsatisfactory as a norm of interpretation, but only by the fact that physics and chemistry, rigorously studied and applied, will in themselves prove that view (1) is absolutely untenable. Such a result is not likely to be obtained, for all indications seem to show that mechanism is the ultimate basis of all biological phenomena. In any event, if further research in chemistry and physics proves that this is not so, the final refutation of our materialism will come from science itself, not from

any dogmatic, prejudiced attitude of conceiving such problems excluded from the realm of science. Until then, the antithesis between the highest forms of evolution, such as mind, human qualities, humanism in general (if it does exist) is experimentally justifiable. Until then, we have not the right to criticize the tendency of science to reduce all our higher manifestations to cut-and-dried physico-chemical laws.

The solution of this problem, which I have endeavored to outline in its diverse phases, will render great economy in the method and object of research of the New Science. Coöperation in the future between the "Natural" and "Social" scientists will expedite its solution.

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CONCERNING THE POSTULATIONAL TREATMENT OF EMPIRICAL TRUTH

§1. *Example of a System of Postulates.* Certain elements of structure are common to all deductive expositions of truth. As a particular science develops and acquires well determined laws it has a tendency to assume a deductive form. If we have before us the body of such a science, geometry for instance, with its terms and definitions and propositions, and we ask how it may be put into most satisfying logical order, we shall be brought to the conception of a system of postulates as the necessary apparatus from which the deductive procedure may begin. We must choose certain elements and relations to be left undefined, at least so far as geometry is concerned, and also certain propositions to be left unproved. These unproved propositions are called postulates. When they are agreed upon and set before us with such descriptive fullness as will lead to a clear understanding of their import we are prepared to go forward with the systematic development of the whole body of propositions which constitute the science.

All this is a commonplace of current mathematical thought. To a greater or less extent these truths have been realized since the days of Euclid (who called by the name of axioms what we now call postulates). Their import and bearing have been discussed by many writers. The main facts of a general nature, which it is necessary for the reader to have in mind in order to understand the present

discussion, have frequently been set forth, and nowhere to better advantage than in Lectures II to IX of Keyser's *Mathematical Philosophy*. All such expositions, so far as I know them, satisfy also certain additional demands not essential to our present purpose. Accordingly, there is more fullness in them than we need now, so that it seems best for us to begin with just such an account of postulate systems as will enable the reader to understand our later argument.

If we are careful, at the outset, to guard against a certain possible error, we may employ for our purposes an exceedingly simple system of postulates—one so simple, in fact, as to risk the danger of appearing to be trivial. This is the error against which the reader must be warned. Though very simple in itself, this system of postulates may serve for us the purpose of exhibiting in a concrete way (and with the least possible complication) certain fundamental properties of postulate sets in general. It has already been employed, for a purpose somewhat similar to ours, in Veblen and Young's *Projective Geometry*. Moreover, it is akin to the more comprehensive system of postulates on which these authors base a remarkable development of projective geometry. A rather full philosophic discussion of Hilbert's postulates for geometry is given by Keyser in the lectures referred to. If one has in mind the fact that postulate systems have served such important purposes in geometry as those already indicated, not to mention their uses elsewhere, he will not be misled by the exceedingly simple (and perhaps apparently almost trivial) character of the example which we are about to give as a concrete definition of the meaning of a system of postulates—an idea which must be clearly in mind if one is to understand what we shall have to say about the postulational treatment of empirical truth in general.

Certain logical notions are necessary in the formation of any set of postulates. That of class is one of the most central. Closely connected with this is that of "elements of a class" and the relation of "belonging to a class." For our purpose, we shall take these as primitive notions, into the meaning of which we do not inquire. We may then set up our system of postulates thus (following Veblen and Young, l. c.):

Let S be a class the elements of which are denoted by A, B, C. . . . We shall need certain undefined sub-classes of S (classes consisting of a part only of the elements of S), any one sub-class of which we shall call an m-class—thus employing for the undefined sub-class a term which is meaningless in itself. Concerning the elements and m-classes of S, we now make the following assumptions:

I. If A and B are distinct elements of S, there is at least one m-class containing both A and B.

II. If A and B are distinct elements of S, there is not more than one m-class containing both A and B.

III. Any two m-classes have at least one element of S in common.

IV. There exists at least one m-class.

V. Every m-class contains at least three elements of S.

VI. Not all elements of S belong to the same m-class.

VII. No m-class contains more than three elements of S.

In this system of postulates (or assumptions), we have two undefined terms, namely, element of S, and m-class of S; we have also one undefined relation, namely, belonging to a class. So far as the miniature mathematical doctrine based on this system of postulates is concerned, these terms are entirely devoid of specific content except in so far as that content is implied by the postulates themselves. We shall see later that the postulates do, as a matter of fact,

very definitely limit the meaning of these terms though they do not make that meaning unique.

Concerning any such system the primary question is that of the consistency of the postulates contained in it. Are there mutual contradictions in the statements contained in the postulates? If so, the system can probably be of no important use; if not, how shall we be assured of that fact? How may we be certain that in deriving the consequences of these postulates we shall never be led to two propositions which directly contradict each other? It is not enough that the propositions which we actually derive exhibit no contradictions. We wish to be assured that it is impossible that the consequences of the postulates can in any way involve a contradiction.

Now the only known test of the consistency of a system of postulates is one which shifts the difficulty from one domain to another. We shall see how this fact is illustrated by the discussion of the consistency of the foregoing set. Let us consider the letters A, B, C, D, E, F, G, each taken three times, all of them being written in an array of three rows and seven columns, as follows:

A B C D E F G
B C D E F G A
D E F G A B C

Now, let us think of these seven letters as affording a concrete instance of the elements of S contemplated in the system of postulates; and let us look upon the elements in each column of the foregoing array as constituting an m-class of S. We ask whether each of the seven postulates is true when the undefined terms are given these specific meanings. Taking the postulates one after the other we find that each of them is verified by the concrete instance afforded by this array; this the reader may ascertain for himself by a consideration of each postulate separately.

Consider what this result signifies. Since each postulate is satisfied for the given array of elements, every proposition which is deduced solely from the given system of postulates, by strictly logical processes, must be true of this array of elements. Now this array of elements does not possess contradictory properties. Hence, no contradictory propositions can result from the given system of postulates. Thus its consistency is established.

If one examines carefully into this argument, he will see that it depends in the last resort on a certain assurance of self-evidence in the verification of the postulates by the array of letters. We seem to ourselves to see by a direct insight (or intuition) that the postulates are true if taken with the indicated concrete meaning; and our conviction of their consistency depends on our confidence in this direct insight. Such, in the last resort, is a characteristic of all so-called proofs of consistency.

To prevent misconception, we should say here that the given concrete instance of elements and m-classes of S is not the only one which verifies the given postulates. To this point, we shall return in a later section.

In the next three sections we shall give some detail of a mathematical sort. This presupposes a certain intellectual maturity on the part of the reader and the willingness to give consecutive attention to the discussion; but no technical mathematics beyond that of the high school is necessary for its understanding. The results of the discussion and the principal notions involved contain all that is essential to what follows. The reader may, if he wishes, pass over these sections rapildy in order to get to the later and more directly useful part of the paper. It will be sufficient if he acquires the general ideas and notes the principal results. He may dispense with proofs entirely, if he prefers to do

so. The details are given for those who wish to go into them and to make it possible for any reader to verify the conclusions stated. The more essential matters are so emphasized that a rapid reading cannot fail to bring them to the attention of a selective mind.

§2. *Consequences of the Foregoing System of Postulates.* For illustrative purposes, we shall now prove certain theorems which are implied by the postulates given in the preceding section. (The reader who desires to do so may dispense with the proofs, reading only the theorems.) Some of the theorems are such immediate consequences of the postulates as to require no further arguments, while others are of a different nature. At the end of each theorem we shall indicate, by numbers in parentheses, what postulates were employed in the proof of the theorem. In this discussion we shall have to ask the reader's indulgence for the introduction of considerable detail; the results are necessary for use in the analysis of the principal matters to be treated later.

1. If A and B are distinct elements of S, there is one and only one m-class containing both A and B; it may be called the m-class AB (I, II).

2. Any two distinct m-classes have one and only one element of S in common (II, III).

3. There exist three elements of S which are not all in the same m-class (IV, V, VI).

4. Each m-class contains just three elements of S (V, VII).

Let A, B, C be three elements of S which are not in the same m-class. The m-class AB contains a third element D so that it consists of the three elements A, B, D. The m-class BC is different from the m-class AB and hence contains an element E which is different from A, B, C, D, so that BC contains the elements B, C, E. Now consider

the m-class AE; it cannot contain either B or D, since it would then coincide with AB; nor can it contain C, since it would then coincide with BC; therefore, AE contains a new element F, so that AE consists of the elements A, E, F. Next, consider the m-class DE; it cannot contain either A or B, since it would then coincide with AB; nor can it contain F, since it would then coincide with AE; nor can it contain C, since it would then coincide with BC; therefore DE contains a new element G, so that it consists of the elements D, E, G.

Let us now examine the m-class defined by each pair of the seven elements A, B, C, D, E, F, G; in each of the twenty-one possible cases we shall find that the third element is one of this set of seven elements. The m-class ABD accounts for the pairs, AB, AD, BD; the m-class AEF for the pairs AE, AF, EF; the m-class BCE for the pairs BC, BE, CE; the m-class DEG for the pairs DE, DG, EG; there remain nine other pairs. Now BF and DEG must have an element in common (by postulate III); since it cannot be D or E, it must be G; the m-class BFG accounts for the pairs BF, BG, FG. Again, AG and BCE must have a common element; since this cannot be B or E, it must be C; the m-class ACG accounts for the pairs AC, AG, CG. Again, DF and BCE must have a common element; since this cannot be B or E it must be C; the m-class CDF accounts for the pairs CD, CF, DF. Thus we know the elements in each m-class determined by a pair of the seven elements A, B, C, D, E, F, G; and there are just seven of these m-classes.

Let us now consider the possibility of an eighth element H in S. If such an element exists then AH and BFG must have a common element. If this were B then ABDH would belong to the same m-class; if this were F then AEFH would belong to the same m-class; if this were G then

ACGH would belong to the same m-class. Each possibility contradicts postulate VII by requiring at least four elements in an m-class. Hence, S does not contain an element H different from all the elements A, B, C, D, E, F, G.

Thus we have the following theorem:

5. The class S contains just seven distinct elements, A, B, C, D, E, F, G; and these occur in just seven distinct m-classes according to the array given in the first section (I-VII).

Moreover, from an inspection of this arrangement of the elements of S in m-classes—now known to be necessary—we have the following theorems:

6. There is no element of S which is in all the m-classes of S (I-VII).

7. If a and b are any two distinct m-classes of S there is one and only one element of S in both a and b (I-VII).

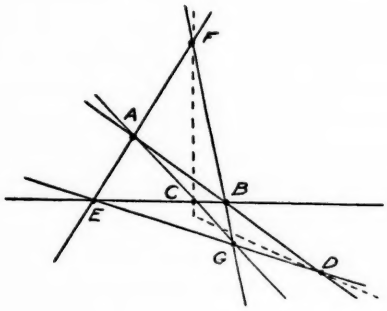
8. Every element of S is in just three m-classes of S (I-VII).

§3. *Interpretations of Systems of Postulates.* In section 1 we gave in the form of an array of letters A, B, C, D, E, F, G, each taken three times, one concrete instance of elements and m-classes of S. We may say that these afford a concrete interpretation of the system of postulates in section 1. In section 2 we saw that in the abstract general case the elements of S which satisfy these postulates are seven in number and that they may be represented by the letters A to G disposed in the same manner as in the concrete instance previously considered.

Let us now examine a second concrete interpretation of the system of postulates. Consider the adjoined figure. Seven points are indicated by the letters A to G and these lie by threes on seven lines (the six straight lines and the

dotted line FCD). If these seven points are taken as the elements of S and the three on any one of these lines as an m-class of elements of S, it is easy to verify that postulates I to VII are all satisfied by such an interpretation.

Let us exhibit still another concrete interpretation of the system of postulates. Let us take for the elements of S the seven triples (100), (010), (001), (110), (101), (011), (111). Let us define an m-class $[u_1\ u_2\ u_3]$ to be those triples $(x_1\ x_2\ x_3)$ of the foregoing set each of which makes the number $u_1\ x_1 + u_2\ x_2 + u_3\ x_3$ even, where $(u_1\ u_2\ u_3)$ denotes one of the seven symbols (001), (100), (110), (111), (011), (101), (010). Then the elements



of these m-classes are in order those in the following seven columns:

(100)	(010)	(001)	(110)	(011)	(111)	(101)
(010)	(001)	(110)	(011)	(111)	(101)	(100)
(110)	(011)	(111)	(101)	(100)	(010)	(001)

It is easy to verify directly that these elements and m-classes of S satisfy all the postulates of section 1. If the elements in the first row of the foregoing array are denoted by the letters A to G in order then this array becomes identical with that of the letters A to G in section 1.

These three concrete interpretations of the system of postulates are very different in character. The first consists of a set of tags or labels denoted by the letters A to G and certain combinations of them; the second is geometric; the third is arithmetic. The theorems given in section 2 apply to each of them. Notwithstanding their difference in the concrete they obviously have much in common in the abstract. From the theorems in section 2 it follows that any two interpretations of the system of postulates must have a certain marked and precise mutual correspondence between their elements. In fact, if S_1 and S_2 are two classes S subject to the system of postulates, every element of S_1 may be made to correspond to a unique element of S_2, in such a way that every element of S_2 is the correspondent of a unique element of S_1, and that to every m-class of S_1 there corresponds similarly a unique m-class of S_2. The two classes S_1 and S_2 are then said to be in one-to-one reciprocal correspondence or to be simply isomorphic. When a system of postulates is such that every concrete interpretation of it is thus simply isomorphic with every other concrete interpretation of it, the system is said to be categorical. Thus the set of seven postulates in section 1 is categorical.

But if the last postulate is omitted the remaining six form a system which is not categorical. For, the concrete interpretations of postulates I to VII form such interpretations of postulates I to VI, while these latter are also verified by the 13 elements A, B, ..., M and the m-classes denoted by the following thirteen columns:

A	B	C	D	E	F	G	H	I	J	K	L	M
B	C	D	E	F	G	H	I	J	K	L	M	A
D	E	F	G	H	I	J	K	L	M	A	B	C
J	K	L	M	A	B	C	D	E	F	G	H	I

§4. *Properties of Systems of Postulates.* Two of the fundamental properties of postulate systems we have already treated incidentally to the earlier discussion, namely, consistency and categoricalness. Nothing more need be said concerning consistency. But we wish to add something concerning categoricalness. We have already seen that a system of postulates may be categorical or that it may fail to be categorical; but we have not analyzed the ways in which it may fail to be categorical. If we consider a set of postulates which is not categorical and examine all the concrete interpretations of that set we shall find that these concrete interpretations themselves fall into two classes such that those interpretations which are in any one of the classes have the mutual property of being simply isomorphic. We may think of the various concrete interpretations in a single one of these classes as being equivalent in the sense of being simply isomorphic. The number of these classes of equivalent interpretations may be said to measure the multiplicity of the non-equivalent interpretations of the system of postulates. The question arises as to whether this multiplicity may be infinite and whether it may be equal to any (whatever) given finite number k. The answer is affirmative for each case. It may be shown that our postulates I to VI, taken alone, are of infinite multiplicity, while postulates I to VI and the following postulate

VII$_1$. No m-class contains more than n+2 elements of S where n is a given positive integer

afford a system of multiplicity k if n is properly chosen. We shall not take the space necessary to prove these statements. We shall merely add that the k possibilities in the latter case arise from the fact that an m-class may have

any one of k distinct numbers of elements, thus giving the k distinct possibilities.

The question arises as to whether it is preferable that a system of postulates shall be categorical or non-categorical. The answer depends upon circumstances. There is often a certain advantage in keeping the set non-categorical as long as possible. Let us make this concrete by means of an example. If we should develop the consequences of our postulates I to VI, without the use of any other postulate whatever, we should have a body of theorems which are true for any consistent set of seven postulates obtained by adjoining another to these six. That other might be the following:

VII_2. Every m-class contains just $n+2$ elements of S where n is a given positive integer.

By varying n over a suitable set of positive integers we have an infinite number of distinct possibilities for the seventh postulate. The consequences of postulates I to VI are true for each of this infinitude of cases. Thus, by starting with a non-categorical set of postulates we are able to develop a common part of a variety of doctrines. It is easy to see how this may result in a great economy of thought. In the next section we shall discuss the implications of this important principle for the development of natural science.

Let us next consider the question of the independence of a set of postulates. If no one of the set can be derived as a logical consequence of the others the set is said to be independent. For our original set of postulates I to VII we have already seen that VII is independent of the others; for the array at the end of section 3 affords a concrete interpretation of I to VI which does not verify VII. Again, if we take the elements of S to be A, B, C, and the m-classes of S to be the pairs AB, BC, CA, then postulates I, II, III,

IV, VI, VII are verified while V is not verified. Therefore V is independent of the other postulates of the set. In like manner, other examples could be constructed to show that each of the postulates I to VII is independent of the other postulates in the set. On the other hand, if we should adjoin to these seven postulates an eighth one reading like theorem 7 of section 2, then we should have a set which is not independent. For some purposes it is not necessary, or even desirable, that the set of postulates should be independent. The bearing of this on the development of empirical truth will be discussed in the next section.

Two other properties of a single system of postulates may be mentioned briefly. It should be fertile, that is, it should have consequences which are not explicit (but are only implicit) in the postulates themselves. It should be compendent; that is, it should not be possible to separate it into two or more unrelated systems of postulates.

If we have two systems of postulates such that those in each system may be derived logically as consequences of those in the other system, we say that the two systems of postulates are equivalent. If we consider the body of propositions in a given doctrine—the postulates and their consequences—as a whole, it is evident that two equivalent systems of postulates give rise to the same body of propositions; it is for this reason that the term equivalent is applied to them.

In section 2 we have already derived certain important consequences of the postulates in section 1. We shall now restate seven of them in a form to serve our purpose for the study of equivalence of systems of postulates, following them by numbers in parentheses referring to the theorems which contain them.

Ia. If a and b are distinct m-classes of S there is at least one element of S in both a and b (7).

IIa. If a and b are distinct m-classes of S there is not more than one element of S in both a and b (7).

IIIa. Any two elements of S are elements of some one m-class of S (1).

IVa. There exists at least one element in S (3).

Va. Every element of S belongs to at least three m-classes of S (8).

VIa. There is no element of S belonging to all the m-classes of S (5, 8).

VIIa. There is no element of S which belongs to more than three m-classes of S (8).

It may be shown that this system of seven postulates is equivalent to the system in section 1. In fact, we have already shown (in section 2) that those in this section may be derived logically from the system in section 1. That those in section 1 are consequences of the system in this section may be shown in a precisely similar manner; the argument is so much like that in section 2 that we may omit it.

This example illustrates one further important fact concerning systems of postulates. Suppose that we have before us a considerable body of propositions (we say nothing now of how they were derived), and that we wish to organize them as far as possible into deductive form. It is necessary to choose a system of postulates from which the deduction may proceed. The example before us shows that this system of postulates need not be unique; there may be more than one way to select it. In fact, a little meditation on the matter will show that there must often be a great freedom of choice for the basic postulates. This is a matter of great importance in natural science, since it allows the investigator a considerable freedom to follow his sense of esthetic fitness. We shall return to this point later.

§5. *Postulates in Mathematics and Laws in Natural Science.* The miniature mathematical science which we have (partially) developed on the basis of postulates I to VII illustrates what is done in more fullness in reducing any mathematical discipline to an abstract and logically connected form. We choose certain terms and relations, one or more of each, which are left undefined; and we select certain propositions which involve these terms and relations and are to be left unproved. These propositions constitute the system of postulates. They serve to limit and restrict the possible meanings of the undefined terms and relations. All other propositions are to be deduced from these by logical processes. The resulting science is purely abstract, is a part of pure mathematics strictly so called. It may have several concrete interpretations. If the system of postulates is categorical any two of these interpretations will be simply isomorphic. Otherwise, there will be two and perhaps many interpretations which are not simply isomorphic in pairs.

One of the principal objects of such an abstract formulation is to exhibit with precision the logical connections of the various propositions of the science. The method has great unifying power and brings out clearly the analogies among things which at first appear to be distinct. In this way it serves an important use in economizing thought. The development of one abstract doctrine may carry with it at the same time the main essentials of that of several or many concrete doctrines. Moreover, it is possible to deal for a while with a non-categorical system of postulates and so develop with a single effort the common part of several or many distinct doctrines either abstract or concrete.

With the conception of a system of postulates in mind, it is easy to make clear what is meant by rigorous thinking.

By "thinking rigorously" one means that sort of process by which one obtains from a given system of postulates and from nothing else but that system some or all of the consequences which flow from that system by logical necessity. There is no implication that this is the only sort of thinking that is legitimate; but it is intended to include all sorts which proceed in a legitimate way solely from a set of postulates to necessary conclusions which they imply. In those parts of natural science which are not essentially applied mathematics, and indeed in some parts of what is often called applied mathematics, the thinking is not strictly in accordance with this ideal. There often are definite hypotheses, or postulates, furnishing a part of the necessary basis of the argument; but these are frequently supplemented with a sort of intuitional knowledge of experimental facts, a sort of incomplete induction, so that the conclusions reached have not been engendered solely by the definite and consciously realized hypotheses, but owe an essential part of their existence to the additional unstated assumptions or conclusions from experiment which constantly appear in the argument. In mathematics, strictly so named, none of these unstated or implicit postulates may be employed. Whenever they are present the thinking is not rigorous in the proper sense of the term.

It is not an easy matter to throw a comprehensive discipline into this strictly rigorous form; and yet we do not properly understand its logical connections until we have organized it in this way. It is difficult, in the theory of electricity and magnetism for instance, to select and establish experimentally those fundamental basic laws from which all the properties of electricity and magnetism may be derived by logical processes alone; and yet, so long as we have not done this, we have not brought the science to that ideal state which is so forcibly suggested as desirable

UMI

by the experience of mathematicians in dealing with the simpler subject matter of their science. In some parts of natural science, as in celestial mechanics, for instance, the achieved success is so great that the theory is almost or quite capable of exposition in a strictly rigorous deductive form. To bring a science into this state requires long labor and the work of many minds. The discovery of the fundamental laws is usually not the achievement of an individual but of a long line of individuals; like many other elements of our civilization it is a racial achievement and belongs to the race. It is one of the fruits of the past, a part of the accumulated wealth from the toil of many generations of dead men fructifying the labors of the living.

The conception of the postulational treatment of a body of doctrine may afford us an important criterion for determining the state of development of a science with respect to its attainment of empirical laws. Are the known laws sufficiently definite to afford the basis for setting up a postulational treatment? Are there among them a few of such central importance that they may be made the starting-point for a rigorous logical deduction of all the others or at least of certain large bodies of them? If this is not so, then one can hardly suppose that the more central empirical laws of the science are yet discovered. In the more highly developed of the natural sciences there exist these fundamental basic laws—laws which may be taken as the postulates in a deductive exposition of a large body of propositions each of which is verified by natural phenomena. In others, and particularly in the sociological sciences, this stage of development has not yet been reached.

Suppose that one considers the body of known laws in some particular science, say for definiteness the science of psychology. Suppose that one examines these laws with respect to the question as to which of them may be deduced

rigorously from the others; and suppose that he finds, as perhaps he would find in the science of psychology in its present state of development, that there is no comprehensive group of these laws which are logical consequences of those in a small set to be taken as a system of postulates. What then will be his conclusion concerning the state of development of that science? He may say that the science in consideration is of such a nature as not to be capable of reduction to a rigorous form after the manner of a postulational treatment, and he may insist that the ideal suggested by the clear conception of a body of doctrine intimately connected logically is not a suitable ideal for this science and that this ideal is as a matter of fact foreign to the nature of this science. There is something which could be said for this point of view. But when he observes that every science which is generally reputed to be in a high state of advancement approaches more or less nearly to this ideal and that it approaches it more nearly as it becomes more highly developed, he may come to doubt after all whether his first position is correct. He may be led to conceive an ideal for the less developed science which is thus so forcibly suggested by the more highly developed. It appears to me that the known fact of the existence of important and extensive bodies of doctrine in the ideal deductive form afforded by a postulational treatment should be kept in mind by every scientific investigator as suggesting a fundamental criterion by which he may estimate the degree of advancement of his own science; and that it should often spur his determination and effort in the direction of singling out the more central and fundamental laws of his science.

It is not necessary, and perhaps not even important, that this ideal should be applied in its strictest form. So far as the advancement of empirical truth is concerned it does not

seem to be necessary that the laws which are selected to constitute the system of postulates for a deductive exposition shall yield a set whose propositions are independent. If one desires to see clearly the logical connections of these laws he will wish to have a system of independent postulates. He may also desire to know several equivalent systems of postulates. But this knowledge can hardly be of much value for the advancement of empirical truth; its importance lies in the help which it gives in penetrating clearly into the logical connections involved.

But there will be a certain gain in economy of thought—and sometimes a great one—if certain important laws can be selected which are rich in consequences and at the same time afford a non-categorical system of postulates, particularly if these laws are common to several branches or divisions of science. The same thing will often be gained by the use of a categorical system with several concrete interpretations. An important example is afforded by the mathematical treatment of several branches of physical science. Let us make the matter concrete by taking an example. (It is not necessary for the reader to understand the mathematical terms; the essential point will be clear to him without this knowledge.) Consider the partial differential equation $\frac{\delta^2 u}{\delta x^2}+\frac{\delta^2 u}{\delta y^2}=0$, where u is a function of x and y. Among the theories in which this equation is fundamental, or at least important, are the following:

A. In pure mathematics:
   In the theory of functions of a complex variable;
B. In physics:
   (1) In the flow of incompressible fluids;
   (2) In the steady flow of heat;
   (3) In the steady flow of electricity;
   (4) In the theory of static electricity;
   (5) In the theory of magnetism.

As we have said, the differential equation is important in the study of each of these widely separated topics. Abstractly considered, there is a certain common body of laws in these several disciplines which gives rise in each of them to the differential equation in consideration. From our present point of view we may look upon these laws as affording a certain system of postulates. One would probably formulate this system in such a way as to be non-categorical; whether he does or not, the example will still serve our principal purpose, namely, to see that the postulational treatment of these disciplines will give rise to great economy of thought; for, whether categorical or not, there are several concrete interpretations of the system, namely, those indicated by the several disciplines of which they form a common part. When one develops the properties of the given differential equation he obtains results which are applicable simultaneously to each of the several named disciplines. Thus a single theory will imply important consequences in each of several directions.

We have said eonugh to make it apparent that the postulational treatment of empirical truth must have important consequences in the development of that truth. This will be more fully apparent in several ways as we proceed with our discussion.

§6. *On the Nature of Scientific Investigation.* The point of departure in the development of science is the living human being. The beginnings are to be sought in the slow and almost unconscious observations of primitive men. Out of the complex of impressions due to interactions with the environment there was a gradual separation of crude facts and these isolated elements of experience became increasingly definite with the lapse of time and the multiplication of instances. After a long period arose a conception of certain uniformities, such as the apparent move-

UMI

ments of the heavenly bodies. A mastery over rude implements was gradually attained and the primitive peoples began to have some tools by the aid of which to increase the security and comfort of their lives. These served at the same time as the means by which their crude investigations were carried forward.

In the more advanced stages of the racial history the point of departure in the development of any new science is still the living investigator. The ancient Greeks appear to have made the mistake of not getting far enough away from this beginning; they attributed too much to the thinker and gave too little place to nature as manifested in the environment, so that they did not learn to properly question her by experiment as to the laws in accordance with which she operates. Their science was too metaphysical. At the origin of modern science the pendulum swung so far in the opposite direction that the importance of the investigator himself was often lost sight of in the midst of the multiplicity of facts and laws which he encountered. But it seems clear that all science is by its very nature a phenomenon of the observer and the observed and that both of them play fundamental roles. The laws of man's spirit as well as the laws of other nature are wrought into the propositions of all science.

To lay the foundations of a science nowadays, it is necessary to begin with an accumulation of facts—and some of these must be the results of measurements if the science is to be exact. It is necessary to examine these facts with respect to the uniformities which appear among them. Here incomplete induction and intuition will play a fun damental role. When a given phenomenon, so far as our experience goes, follows regularly upon the appearance of certain other phenomena we conclude that it is connected with them by some sort of law, and we form an hypothesis

as to what that law may be. Often we find it necessary to discard an early hypothesis in favor of one later formed in the presence of a more comprehensive body of facts. Thus, with more or less change and after a longer or shorter period of testing, our hypotheses are modified and extended and refined until they come to appear to us to be veritable laws of nature. Our science is then approaching a stage in which the investigators can begin to look upon it somewhat as an actual existent entity which they can behold as exterior to themselves.

It is at this point that a critical analysis of the developing science can be profitably made. The workers begin to see connections among the laws and to single out some of them as more fundamental than the others. There is a tendency to consider some of these more central laws as affording the causes of some or all of the remaining laws in the science, and the logical deduction of some of these from the others begins. Though some freedom in the matter may be allowed to the investigator by the nature of the phenomena, yet these causes cannot be chosen at random. If they are to play the role of postulates in a deductive exposition of the science—and this is what they have a tendency to become—they must be selected in such wise as to afford a suitable starting-point for the chain of deductions. When the science has reached a stage in which these central laws or postulates can be singled out with some completeness its exposition tends to assume a strictly deductive form. In a book on geometry or rational mechanics or theoretical physics there is little of incomplete induction or intuition in the processes of analysis, however much these may have been present in the discovery of the laws which are developed, and the procedure is dominated by a certain logical necessity in the connections of the proposi-

tions, often to the exclusion of all other processes of thought.

For our present purpose it is necessary to see clearly that these fundamental laws in a natural science play a role in it precisely analogous to that of a system of postulates in mathematics—such a one, for instance, as we have exhibited in the miniature mathematical science of which we have given a partial exposition. It is true that an empirical part of the science must precede the systematic exposition in which this has place; but it is also true that the science is not in a satisfactory state of completeness until expositions of it exist in this systematic form. We need not examine now the relative importance of these two parts in the development of a science; it is sufficient to our present purpose to observe that both of them are essential.

When these fundamental laws have been set apart and the known empirical laws have been deduced from them there is left the problem of ascertaining what other empirical laws are implied by the fundamental ones already investigated; thus the exposition will itself yield predictions of new empirical laws not yet recognized. In this way it may contribute to a veritable advance of the science; as a matter of fact, it has often done so in the past.

If one reflects how poorly defined are such terms as matter, energy, force, one may begin to see that the so-called laws of mechanics are not so much laws about well-defined entities as they are postulates serving to define the range of use of fundamental terms not otherwise strictly delimited in meaning. As we have seen, this is precisely one of the important functions of the system of postulates in a mathematical science. In the example which we have treated the terms "element of S" and "m-class of S" were entirely undefined except in so far as they were restricted by the propositions concerning them contained in the sys-

tem of postulates. This did not restrict them, as we saw, to a single concrete interpretation; but in the system to which we gave our principal attention it did so restrict them that all concrete interpretations of the postulates were simply isomorphic. Such a restriction of the meaning of the terms would be quite enough for most of the purposes of natural science. Then, if the fundamental laws are treated as postulates are treated in a mathematical science, the investigator can obviate a large part of the difficulty which he must otherwise feel with respect to the definitions of terms. From this point of view the basic propositions of a science need not be so much the statement of empirical laws as of the postulates from which the deduction of the empirical laws may proceed. They justify their use if they lead logically to the empirical laws and to no propositions which are empirically invalid. Thus the postulates need not necessarily have an empirical validation; it is sufficient if they yield the empirical laws. Thus, the so-called law of the conservation of energy is by its nature incapable of direct empirical validation; our reason for employing it is that it leads logically to empirical laws.

These considerations bring us to a contemplation of a new aspect of physical science. What does it signify to say that the basic postulates of a science need not necessarily be laws which are capable of a direct empirical validation? Certinly it brings into prospect a new freedom of the investigator in seeking what is to him the most satisfactory form of exposition of a science sufficiently advanced to be subjected to a postulational treatment. If he desires to do so, he may go back of what is directly given in experience and create new "causes" to underlie and "explain" the phenomenona which he finds. In a certain sense he can impose his own spirit upon the phenomena. The general conception of such a procedure is usually repugnant to the

natural scientist, though in practice he not infrequently resorts to this very method. As already indicated, his use of the law of the conservation of energy is of precisely this nature. But we can also find examples of a less comprehensive sort. When the fundamental hypotheses of the atomic theory were introduced they had just this character. It is true that there is nowadays some almost direct empirical evidence for the basic hypothesis; but it was not so in the early history of even the modern atomic theory. The requirement of the covariance of the laws of nature under transformations in the four-dimensional space-time world, in the Einstein theory, has much the same character of freedom from direct empirical validation as that which we are now insisting upon as a possibility for the fundamental propositions in a postulational treatment of science.

Among the advantages of a deductive exposition of science based on a system of postulates is an important one to which we must now give some attention. It enables us to localize the doubt in case the supposed laws of phenomena lead to contradiction with empirical fact or merely to conclusions which are mutually contradictory among themselves. If these contradictions exist and if rigorous thinking concerning phenomena is possible, then the initial error must be in the postulates themselves. Thus we have a small body of propositions among which to find the error. We are enabled to concentrate our attention at once upon the kernel of the difficulty.

In the presence of such a situation, we cannot fail to raise the question as to whether the laws of our spirit are conformable to the laws of the external world. It is probably a question which we cannot answer with certainty. But if there is not some conformability between the two then we must conclude that natural science is impossible.

This is too repugnant to be accepted by us except under compulsion. Moreover the measure of success already attained in the development of science appears to belie the conclusion. The only course left open to us seems to be to assume this conformability, or at least to act upon the hypothesis that it exists. This we have done in the past, perhaps somewhat unconsciously, and this we shall probably continue to do in the future.

If in a postulational treatment of empirical truth we are faced with a situation involving a contradiction, so that we are under the compulsion of changing the conclusions reached, we have no possibility before us except to change the postulates from which we start. But, as we have already seen from the analysis of our miniature mathematical doctrine, we may change the system of postulates without changing the total body of propositions (in postulates and conclusions) of which our body of doctrines consists. We shall need to replace our given system by one which is not equivalent to it; moreover, we shall have to replace it by one having no concrete interpretation (of any sort) in common with the one which we seek to modify so as to avoid contradiction—a fact which will be apparent on a little reflection.

In proceeding to the task of revising or modifying our system of postulates so that it shall realize the known empirical laws and avoid the consequent proposition or propositions which we now know to be false, it may be that we shall have to reconstruct the system entirely. This will not mean that our previous labor has been without value, for the earlier organization into a postulate system and consequences will facilitate the newer organization which must be undertaken. In this way a constant interaction between our postulational treatment and the empirical laws will yield a side by side development of the two. It is much

in this way, as a matter of fact, that science has advanced. We are urging that it shall do so more consciously and more systematically. A method which has proved of so great use wherever it has been employed should be thoroughly utilized in every domain of thought which has become exact enough to allow its use.

The contradictions of which we have spoken are of two sorts: there are those in which the conclusions from the postulates involve mutual contradictions; and there are those in which mutual contradictions among propositions are absent but at least one conclusion is in contradiction with experience. We may be sure that in the first case the mutual contradictions among propositions also involve contradictions with experience, even though we have not been able to show this by an experiment. Otherwise there would be an absence of conformability between the laws of our spirit and the laws of the external world. In mathematics we have always been able to test our system of postulates for consistency; and we do this by means which depend for their effectiveness upon the fact that the system of postulates contains undefined terms. (We have illustrated the method by the aid of the miniature mathematical science already considered.) But in the physical sciences we have usually thought of the basic terms in the system of postulates (that is, in the system of fundamental laws underlying the whole body of the science) as being defined in their relation to physical phenomena. But certainly, so far as questions of consistency in the system of postulates is concerned, it is not necesary to give them this meaning. We may think of them as undefined terms and treat them for the moment just as we do the corresponding terms in a mathematical science. We shall therefore have at our disposal the same means as the mathematician employs in his tests for consistency. This should make it possible for

us to determine in advance the mutual consistency of our system of postulates and to introduce corrections if these are needed. Then the contradictions to be treated will be only those which violate experience. In that case, experience alone (in the form of controlled experiment) can enable us to obviate the difficulty.

§7. *Stages in the Progress of Science.* A principal interest of the young child is to exercise his power over things. He enjoys the marvelous results of his own acts. He is conscious of exercising force upon his ball and of seeing the ball change its position with reference to his body or other objects about him. In a vague way he thinks of the force which he has exerted as the cause of the motion observed. As his experience widens and he passes toward maturity he finds that there are some things which are not under his power nor under that of others whom he sees. It rains, and neither he nor his associates can prevent it; it is clear, and neither he nor his associates can make it rain. What is more natural in this situation than to do what our primitive ancestors did when they assumed that such phenomena were due to the power and the will of beings somewhat like themselves but endowed with much greater strength and perhaps even with omnipotence. This gave an explanation of phenomena which satisfied their primitive requirements. Thus arose mythology as the first explanation of the nature of things.

It is obvious that such a theory does not lend itself readily to a postulational treatment which is effective. The nature of the gods is not sufficiently well known—and suitable hypotheses concerning them do not seem to be possible—to afford the starting-point of a logical deduction. To attribute to them omnipotence does not help the matter—at least so far as obtaining control over nature is concerned. As long as human thought remains on this level

the conception of a postulational treatment of truth cannot arise.

Perhaps the first phenomena in which important uniformities were observed were those of day and night and the phenomena of the heavens. These are very striking in their character; they are easily observed; they are the most regular of those which are inevitably impressed upon our thought. To astronomy we must look for the earliest development of scientific ideas properly so called. The remains of prehistoric peoples show that a certain amount of accurate astronomical observation had been made in an early age. Some of this surely passed into the hands of the Greeks before the beginning or at the dawn of the marvelous scientific development which took place among them. To them, of whom Thales of Miletus (580 B. C.) is regarded as the first, we must go for the earliest advance on the mythological view of nature. Acquired facts and the power of a strictly logical deduction first appeared in the Greek mind, and a postulational treatment of truth then became inevitable.

We must guard against the error of looking upon the earlier (the mythological) developments with too much disfavor. There can be no doubt that these explanations—foreign as they are to our ways of thinking—were very helpful in the earliest organization of observation and in breaking it into suitable parts for analysis. "A false theory which can be compared with facts may be more useful at a given stage of development than a true one beyond the comprehension of the time, and incapable of examination by observation or experiment by any means then known." The Newtonian theory would have been useless to our primitive ancestors; but their mythological explanations brought conviction and directed their thought in helpful ways. The ancient atomic theory bore no direct fruit till

it was revived in modern times after the possibility had arisen of subjecting it to experimental test; but it now holds a fundamental position in physical science.

Returning to the ancients, let us consider the rise of postulational methods among them. These methods made their first appearance in geometry but not in the empirical geometry which was first developed. The science had its beginnings, so far as the record goes, in the practices of the Egyptian land surveyors. With them it was purely empirical. They were concerned with working rules by which land might be measured or by which it might be divided so that a father could justly apportion his holdings among his sons. The Egyptians knew only that arithmetic which is indispensable for practical computations and that geometry which practical life constantly demanded; and even this they knew only imperfectly; the rules they gave sometimes led to results which are far from accurate.

But when these empirical truths were transplanted into the Greek mind they received a remarkable fructification and entered upon a new life which has since then been intimately connected with the most far-reaching developments of exact thought in every direction in which it has gone. The Greeks were not content with practical rules. They sought to go behind them to the more fundamental principles on which they depended. One result of this was to extend and improve the practical rules themselves; but it is not this upon which we wish now to place the emphasis. Their thought gave birth to the science of geometry in the sense of a body of truth in deductive form.

They accomplished this primarily by means of what they called axioms and we today call postulates or assumptions. The significance which they attached to these basic propositions was different from that which we give to them today; but this need not detain us. The momentous thing

for human thought was the fact that a form of postulational treatment had arisen and had been brought clearly into the focus of attention. It presaged the death of all mythological explanation and foreshadowed, however faintly, the day when a postulational treatment of empirical truth would become the ideal of every science.

An incidental matter of great importance should have brief mention in passing. As the Greeks conceived geometry it was a veritable science of the space of experience. Nowadays we look upon the matter in a different light. Besides such geometries as they knew we have the so-called non-euclidean geometries. Abstractly taken, these several geometries are inconsistent with one another. They cannot all have been dictated by the space of experience even though this space released those forces of our spirit which gave them existence. The question of how geometry is related to the space of experience therefore has a different meaning to us from that which it had to the ancients. Its consideration has led to a realization of the fact that the geometry of space varies profoundly with a varying choice of the units of measurement. If we had defined the unit of length as the distance through which a body would fall from rest in a second and had proceeded with this unit to explore the regions on the earth, under the earth and above it, we should have had very different conceptions of the nature of space and the relations of material bodies to it from that which we get by means of our customary units. The space so explored would not appear to us to be euclidean, our laws of motion would be different, and even so fundamental a thing as the principle of causality would not be valid (at least without important modifications in its applications). The nature of the space of experience and the course of phenomena in it, as we represent them to

ourselves, would have a greatly changing character if we should modify our units of measurement.

Let us return to the course of science in its development. There was considerable progress in astronomical speculation among the Greeks, especially after the impulse given to it by Pythagoras and his followers. The earlier explanations were often too simple in form for the complexity of the facts; and some of the ancient theories underwent a process of complexification which ultimately broke down under its own weight. The "postulates" which served for a time had finally to be abandoned. But observations accumulated and later a great mass of these fell into the hands of Kepler to bring forth through him a great fruit of new laws. Later Newton was able to set the postulate of universal gravitation back of Kepler's laws and astronomy took on a new form and acquired a new dignity. It became the first science of phenomena (properly so called) to become essentially postulational in the form of its exposition. Every one interested in the progress of thought knows what a fundamental advance in celestial mechanics ensued.

But this is not all. The ideal as to the form of truth implicit already in geometry received new attention when it was first realized in a science of phenomena. Celestial mechanics became the norm by which the state of advancement of other sciences was measured; and they received a great impetus from the effort to realize in them a new ideal of excellence. Rapidly followed the reduction of terrestrial mechanics to the form of an essentially postulational treatment. The basic propositions were (and are) called laws, rather than postulates, but this need not be allowed to obscure their essential nature. This raised still further the hope and the expectation that all science shall be re-

duced to the ideal form at this time exhibited in geometry and both celestial and terrestrial mechanics.

We cannot pass over this opportunity without emphasizing anew the fact of the non-passivity of the human spirit in the development of mechanics. In the first place it was actuated by an ideal which prompted the direction of progress; important as this was it is perhaps overshadowed by another fact which has received less attention. We have already intimated it in earlier remarks. The laws of mechanics depend in a profound way on the definition of units of measurement. As J. Rueff has shown so clearly (see reference in next section) this choice has been dictated by the demand of the human spirit that the principle of causality should be maintained. Nature has characteristics which make it possible to maintain this law; but the human spirit has been active (and not passive merely) in selecting the units of measurement so that the principle can be maintained. In a certain sense the human spirit has thus imposed itself upon nature; but nature was such in the first place as to render this possible. There appears to be a real solidarity between the human spirit and the external world.

With the expositions of geometry and mechanics in a postulational form the way was open for the like development of all other sciences. We may pass over them rapidly, indicating only the most salient facts. Progress towards a postulational form has perhaps not been continuous throughout the whole body of science, but it has on the whole been rather rapid. The other divisions of physics were the first to realize more or less fully the new ideal. Chemistry has made considerable progress in this direction but not by any means so much as the theory of electricity and magnetism, to name a branch where the success has been remarkable (since the formulation of Maxwell's

theory). Recently physics has been in a state of turmoil in which new basic postulates have been sought and found. The older system was not sufficient for the newer facts and a new system is now in process of construction.

When we pass beyond the domain of the physico-chemical sciences we find progress towards a postulational basis of exposition far less advanced. Geology, with all its successes, lags far behind. Biology has obtained important laws, that of evolution for instance, but it cannot yet be put in deductive form. Psychology is still further removed from the goal and the confusion which characterizes it today does not promise immediate success. Economics is struggling towards the ideal, as we shall see more fully in the next section. Sociology is only far enough along to to be getting its empirical bearings; it is far from the state in which a deductive exposition is possible. And ethics and esthetics are hardly ready to hear with patience the suggestion that they be organized as they must be if a successful and adequate postulational treatment shall become possible.

It may be urged that this ideal which arises through the successes of mathematics and mechanics and the physical sciences is not a suitable one for these other disciplines. This possibility we have already considered briefly. It is sufficient to repeat that such an ideal cannot be harmful to these sciences, that it holds out promise of value to them, and that it is probably correct in its insistence that it is the lack of development of them which makes it now impossible for them to realize this beautiful ideal in the form of their exposition.

§8. *A Postulational Treatment of Economics.* In *Des Sciences physiques aux Sciences morales* (Alcan, Paris, 1922), a little book which has been useful to us in certain preceding parts of this paper, Jacques Rueff proposes an

interesting method for reducing economics to a deductive form. This method is developed under the direct guidance of the ideal afforded by the existent postulational treatments of natural science, especially that of rational mechanics. It seems useful to give a brief sketch of his method since it embodies the results of the latest effort to develop science in the direction which we have considered; moreover, such a sketch will serve for us as a helpful illustration of the methods which we have urged.

Rueff does not propose to develop a complete rational theory of economics. He wishes to show only that such a theory is possible and to examine its nature. For this purpose he announces certain principles which can serve as its basis and shows that the first theorems which follow coincide with empirical laws already discovered. In economics one finds already some chapters which present the main characteristics of a rational (that is, deductive) exposition. Rueff proposes a method for founding such a treatment of the whole science.

It is necessary to begin by defining certain symbols, or terms, and setting up certain postulates (axioms, he calls them) which serve to define the use of these terms and to afford the starting-point of the argument; he wishes to be able to develop in a simple and rigorous manner all the empirical laws already known and to lay the foundations for discovering others which have not yet been suspected. In the definition of terms he is guided largely by the analogy of rational mechanics. The use and definition of the term force in the latter directs him towards his primary definition. We perceive that the movement of objects is brought about by the effort which we exert upon them and we are led to suppose in principle that all the movements of material bodies are brought about by something akin to the effort which we put forth; we are brought to the con-

UMI

ception of force as the cause of the motion of material bodies. Now the force of which we are conscious is not suitable, in the form in which it appears in our consciousness, to furnish the central term in a rigorous logical development; in particular, it is not sufficiently clearly defined for mathematical purposes. We must be able to measure it before we can give it a place in our mathematical equations. There is no disposition to say that we measure a state of our consciousness or even the effort of which we are conscious. We merely introduce a conventional definition suitable to serve the purpose of argument and to lead to known empirical laws. We say that the force is defined to be the product of mass by acceleration, that is, the product of mass by the rate of change of velocity with respect to time, or again simply the rate of change of momentum.

If we inquire what it is in the exchange of merchandise, let us say in the movement of merchandise, that takes the place of force in mechanics, we shall be led to the conception of one's "need" as the "force" which causes him to seek to acquire the merchandise that he wants. In order to use this conception in a mathematical discussion it is necessary to have a definition of its measure. There is no intention to say that we must find a measure of the need as felt psychologically; that may well be impossible. What is sufficient for the immediate purpose is to be able to assign such a measure to need as will enable us to use it effectively in deriving deductively the empirical laws of economics. It is legitimate to give to need a mathematical definition which will serve this purpose without inquiring whether this definition affords the measure of the need as we actually experience it psychologically; just as it is legitimate in mechanics to form a like definition of force. The only question we have to ask is that of the suitability of the definition to furnish the starting-point of our science.

UMI

Again the procedure of mechanics suggests to Rueff the direction in which to look for his definition; and he defines one's need n to be the rate of increase of q with respect to the rate of decrease of p where q denotes the quantity of a given merchandise which one has and p denotes the price at which he can purchase it; mathematically, $n = -dq/dp$.

Then his first postulate reads as follows:

I. The need which we have for a certain merchandise decreases when the quantity which we have of it increases.

The need then decreases from a certain value corresponding to zero possession towards the zero of need when possession rises to a certain point marked by satiety; with further increase of possession the need remains at zero.

Before stating the second postulate it is necessary to introduce the notion and the definition of utility. Again we require merely a conventional definition which will serve properly the purposes of a mathematical development. Now the need n is a certain function $f(q)$ of the quantity q possessed. The utility U for a given possession Q is defined to be the integral from o to Q of $f(q)$ with respect to q. (The non-mathematical reader will be able to understand the main points without having a precise conception of the meaning of this definition; it will be sufficient if he remembers that the utility depends in a defined way upon one's need.) Then the second postulate may be stated in the following form:

II. Each individual possesses wealth in a finite quantity and seeks by means of exchanges to acquire wealth in different objects in such a way as to bring to a maximum the sum of the respective utilities of the various sorts of things which he comes to possess.

These two terms, need and utility, and these two postulates afford the starting-point of Rueff's deductions.

UMI

From them he proceeds to derive some of the empirical laws of economics. We need not follow him further in detail. It is sufficient to indicate the character of what he achieves.

In the first place, from this postulational foundation he deduces several of the recognized fundamental empirical laws of economics. Some of these are the following: When an individual possesses two sorts of merchandise A and B in given quantities their total utility to him is a maximum when the ratio of his need of A to that of B is equal to the price of A with respect to B, and conversely; when the price of a certain sort of merchandise increases, the demand for it decreases; purchasers seek to buy at the lowest price possible; the price of a sort of merchandise tends to take a value such that supply and demand become equal.

These will serve as samples of the results deduced from the given postulates. But the latter will not suffice for the whole of economics. Rueff shows briefly how additional postulates may be introduced in order to arrive at the less central results which belong to the divisions of the subject. He has carried the work far enough to make it apparent that the method is capable of extension to the whole science of economics. Thus he has shown that economics is a science in precisely the same sense as that in which geometry or physics is a science and moreover that it is such that its exposition may be put in the form of that of these sciences.

The value of an exposition of economics in such a form cannot be doubted. It is of the same sort as that of other scientific theories which have been so expounded. It gives us a logical and rigorous explanation of observed phenomena. In this way it answers to a need of our spirit, just as the atomic theory does. It should enable us to discover economic laws which are verifiable empirically. In this way it should be capable of giving an important im-

petus to the development of economics; for it is usually much easier to test a law once conceived than to come to suspect its existence in the first place. It shows the existence of fundamental functions and points the way to a study of their properties and perhaps even of their forms; this will make it possible to read new meanings from statistical data. It points the direction in which further investigation is most likely to be useful.

But these laws cannot enable us to predict the distant future; they allow us only to foresee what will immediately follow a given state. After a period of revolution or even after a long period of steady progress the state of society may become so modified that new laws must be sought. This is analogous to what happens in physical science when a new kind of phenomenon is discovered, like radioactivity for instance when first observed; it is necessary to lay anew some part of the foundations to make place for the new structure which becomes necessary.

Such a theory does not directly throw new light on the ultimate character of economic phenomena, on the nature of things economic so to speak, any more than a corresponding development in physical science can yield directly a more penetrating insight into nature. It works by indirect means; it gives us a new tool of discovery; it leads us to unsuspected empirical laws; and it is the revealing of these which constitutes its greatest value in aiding toward a deeper understanding of things.

§9. *The Case of Ethics.* Rueff rightly urges that we should go further with the postulational treatment and bring under its power the sciences of ethics and esthetics. The empirical branch of ethics deals with the maxims or rules of right conduct. At a certain epoch and among a given people these rules are fairly well determined and are generally admitted much in the same way as the empi-

rical laws of the physical sciences are generally admitted. It is true that many people often fail to live in accordance with them; but this does not interfere with their existence as rules of the "should be"; and they deal with what should be rather than with what is. Perhaps the first men had no more conception of duty than they had of causality; both of these grew up with their experience and have taken their present form after a long process of evolution. These moral rules must not be taken in isolation and independent of the life of man; they are a product of the racial experience. Their existence is as certain as that of the laws of physical phenomena. They constitute a moral reality as certainly observed and experienced as anything within our knowledge. Perhaps they could be different; if we had developed in a different way we would probably (almost surely) have formulated different moral laws. The evolution of those which we actually have has been a part of our evolution. You shall not kill; you shall not lie; you shall respect the rights of your neighbor; you shall love your parents; you shall be honest, generous, charitable, industrious, temperate, . . . these are parts of our body of empirical moral laws. They might perhaps have been different; but such as they are they now exist as part of our social order.

With these laws before us the demands of a rational ethics take some such form as the following: Determine suitable general postulates and definitions, however artificial some of these may be in themselves, of such sort that we may proceed from them by rigorous thinking to such propositions as will include all the empirical laws of ethics and nothing in contradiction with them; and then develop these empirical laws in this way. This means that the empirical laws themselves must be reduced to definite form in order that the comparison may be effected. In the proc-

UMI

ess of this logical deduction it will almost surely happen that some of these laws which have been only imperfectly formulated will be reduced to more exact form; it will then be necessary to ascertain with precision whether this more exact statement of the laws is actually conformable with experience. In addition to this we may expect also, if the case of physical sciences leads to correct conjectures, that certain laws will emerge which hitherto had not been apprehended or suspected. It will be particularly important to check these with experience. If they are verified a real advancement is realized. If they are not, it will be necessary to modify the postulates. In this way we may set up an interaction between the postulates and empirical laws which will lead to the development of both. This appears to me to promise much for the advancement of ethics; it has certainly been fundamental in the development of physical science.

The experience of the geometers suggests a possibility which has been brought out clearly by Rueff in an incidental remark. Just as we have several geometries each consistent so far as its own propositions are concerned but incompatible with the other geometries, so may we have several sciences of ethics each entirely free of internal contradictions but incompatible with the others. At most, one of these can be applicable to life at a given time and place; at most one of them can be true in this sense. But one cannot refute any one of them by a consideration of its internal structure; for there is no contradiction of its parts with one another. The only way in which one of these false doctrines may be overthrown is to bring experience to bear upon it and thus to ascertain whether it can bear the scrutiny of life. Among several ethics, each consistent in itself, we can choose the right one only by the aid of experience.

Not a few treatments of ethics have been largely rational in form, and some of them almost entirely so. Such a one is the theological ethics based on the will of God as the criterion of right. The hypothesis of a valid moral judgment as to right and wrong in the conscience of every one has been made to serve a similar purpose. Various other systems have also been constructed; but we need not go into them in further detail. "The reading of a book on ethics is for a scientific mind a source of profound astonishment. The systems are innumerable, the conclusions are unique. Whether the ethics expounded is religious or utilitarian, finalist or pragmatic, it leads always to a well determined set of rules which are, with small variations, the customary ethics of our civilized world."

From the analysis of our illustrative miniature mathematical science we have seen how this might naturally be so. There is such a thing as two distinct systems of postulates being entirely equivalent in the sense that the total body of propositions contained in one set and its consequences is the same as the corresponding total body of propositions from the other set, the two systems differing only in the order in which they derive the propositions and the connections which they exhibit among them. What is found in the case of ethics is something similar to this though it is not precisely the same thing. The systems are not entirely equivalent. They may yield the same laws of conduct so far as the practical life is concerned, but they are different with respect to some of the more or less philosophical propositions contained in them.

The failure of these systems to be precisely equivalent suggests one further remark. They differ most in the things furthest removed from rules of conduct. Perhaps the reason for this lies in their having gone too far from the actual experiences of life itself to find the postulates

(or laws) on which to base the deductions. Perhaps suitable postulates may be found in the body of each comprehensive system or lying close to it to serve as the foundation of the essential parts of that system. If the systems are restricted in the way suggested by this remark they may well approach much nearer to logical equivalence. The answer to the question thus raised lies in the future.

The tendency in the past has been to seek postulates which may be directly established, often by some transcendental argument, whereas the suggestion afforded by experience elsewhere with postulate systems directs us rather to look for such postulates as will lead to the empirical facts without so much regard to the immediate plausibility of the postulates themselves. There was a time when physical science proceeded somewhat as ethics has proceeded in the past—with the help of transcendental arguments. The passing of that day in physical science marked the beginning of an epoch in which its progress has been remarkable. Postulates and definitions without transcendental support have been found more useful than those with it. It appears to me that ethics needs to take a step similar to that which released the development of physical science. Such a procedure may deprive its basis of the glory of the categorical imperative; but this is probably an appendage with which it may dispense without loss. Will the change lead to skepticism? I do not believe so. The explanations will be less transcendental but they will be closer to life; the latter is certainly a gain and the former perhaps is also. The experience of other sciences has shown that the method is helpful elsewhere. Ethics awaits this fundamental step in its development.

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THE STATIC AND THE DYNAMIC IN THE LOGIC OF SCIENCE

IT is the thesis of this paper that a logical parallelism pervades all disciplines of thought—science, philosophy, logic—the parallelism of the static versus the dynamic.

In biology, for example, are to be found the two interdependent but mutually exclusive treatments of data, anatomy and physiology. In anatomy the point of view is structural; the purpose is to ascertain the structural units of the human body—the cells and their groupings into tissues, organs and systems of organs such as the digestive, the circulatory and nervous systems. From this viewpoint the body might just as well be dead as alive; organs are defined in terms of their constituent cells or in terms of their shape, size, position and the like. No thought is given to functions or activities; the question is asked: "What is there?" In physiology the point of view is quite different. Here anatomy is taken for granted; cells, organs and systems are regarded as the tools of life processes. Organs are defined in terms of the work which they perform; the purpose is to ascertain what is happening in the human body and the question is asked: "What does this structure or organ do?" or "What processes are here going on?" The data, then, are dynamic processes, actions, interactions, processes of motion. Anatomy becomes means and physiology the end. How different the two points of view and yet how mutually dependent!

In chemistry, we find a similar state of affairs, but for practical reasons the distinction between the static and the dynamic is not made so prominent. The elements are the

UMI

chemist's anatomy of the physical universe; these elements combine into compounds of varying degrees of complexity and these are called substances. This represents the static point of view. On the other hand, the dynamic point of view is represented in such a concept as that of chemical interaction.

In physics a parallelism is found between such concepts as those of mass and force on the one hand and motion or "work" on the other. In mathematics, number falls within the static concepts while processes of adding, subtracting, multiplying, dividing, *et cetera,* are concerned with "activities" of numbers, *i. e.,* numbers are used as the units or structures of mathematical operations.

Psychology does not escape from this parallelism between the static and the dynamic. We have had our "structural" psychology the aim of which has been to analyze consciousness into its component "states" or "elements," and our "functional" psychology in which the aim has been to describe these processes in action. This problem has cropped out in the literature again and again under the guise of "act versus content" or structure versus function. The question has often been asked: Is an idea a state or an activity? Is it merely an inert thing or does it actually do something?

In the field of philosophy, the same parallelism is quite as marked. It is found between being and becoming, matter and motion, substance and action or the thing and the thing in action. In epistemology the same parallelism is found between knowledge and knowing, the apparent and the real. In logic the same situation holds between terms and relations, quantities and qualities, a property and the "thing" by implication thus qualified by the property, the finite and the infinite, and lastly, the absolute and the relative.

UMI

We have said that states and activities were mutually exclusive, but dependent members of a parallelism. Risking the ambiguities and attending dangers of a dialectic, let us see what this statement means. States, units, properties, quantities, elements, cells and all the rest of the structural and static family are by definition absolute and finite; moreover, they are arbitrary. They are all parts of some whole, and steps or stages in some continuum.

A biological cell, for example, is a crude structure. By observation we discover that it has a certain size and shape but theoretically there is no place at which to draw a line between one cell and another; *i. e.,* a cell is, by definition limited and for practical purposes it is found to be limited. Its boundaries, however, have no *real* existence and are therefore arbitrary. Likewise the chemical element is theoretically a crude affair whose apparent, stereotyped and simple structure becomes arbitrary when we contemplate the facts of radio-activity and reflect that after all the chemical observation is relatively crude compared to theoretical possibilities.

Likewise the sensation and image as structures or contents of consciousness are arbitrary. A limit or boundary is implied and indeed is observable as long as one does not become too critical or analytical in his observations.

Units of space and time are also arbitrary. Even the startling discoveries of Einstein fail to remove from our concepts of these units the implication that they are fixed and absolute. Let us assume for the sake of the argument that under one set of conditions a meter is shortened and under another set of conditions it is lengthened. How is such an idea conceivable unless there is an implied and absolute standard of a meter? For a shortened meter, or a meter which is less than a meter implies a variable and a standard by which a change in the variable can be com-

prehended. A second of time is conceivable as shorter or longer than was previously thought only as it is compared with an implied, arbitrary and fixed unit. A shortened second means a second which is shorter than some other second. Of course, the standard may vary; nevertheless, by implication it is fixed.

Quantities of all sorts fall into the same category of things static, fixed, arbitrary and absolute. For example, "1" is a fixed quantity. By it we do not mean anything less or greater than "1" no matter how slight. It is also arbitrary in that there is no logic about it; one can't put anything into it or take anything out of it without either making it a fraction of itself or without changing it to one and a fraction.

It is the same way with a part of anything. Either a part obtains definite boundaries because of relatively crude observations or its boundaries are arbitrarily determined for the practical purpose of describing the phenomenon in question.

So far, we have been considering only one general type of static concept—the structure, element, part or content. There is another general type within which fall such phenomena as properties, aspects, modes, or characteristics. For example, weight is a property of all physical objects; speed or velocity is a property or aspect of motion; contractility is a characteristic of muscular tissue; shyness is a certain mode of behavior. All such expressions have a static connotation; they represent conditions or states of affairs. They are expressible in terms of quantities, *i. e.*, each is present in a certain amount or represents a certain quantitative value. Each implies something which is quantified. Velocity implies velocity of something—motion; weight means weight of some object; contractility means contractility of something—muscle; shyness implies an

organism which is shy and so on. Moreover, these properties or characteristics are like structures, parts, units or contents in that they are absolute, arbitrary and fixed, except as they are considered abstractly.

Now, then, of what are these things the structures? Of what are these phenomena the properties? Obviously the dynamic. The cell and combinations of cells are the structures of life processes. Sensation and image are the contents of a flowing consciousness; numbers are the structures or elements of mathematical operations; ions, atoms, and chemical elements are structures of energy; and as we have already seen, properties, characteristics and modes are features pertaining to the dynamic.

Turning now to more abstract situations the same case can be made out for our concepts in philosophy and logic. Being is a state, a quantity. It might be regarded as a cross-section or an arbitrarily limited part of something, but of what? Becoming. As a state, being is arbitrary and absolute; it implies "so much of something"; like all states and conditions it is conceivable only in finite terms.

Much has been said in philosophy about the relation of appearance to reality. It is quite obvious that these two terms do not mean the same thing; they are mutually exclusive. Appearance bears the connotation of something unreal or illusory as offset against the actual or real. The relation between the two is exactly that between the static and the dynamic. Appearance is unreal or illusory in the sense that it is arbitrary. Yet, it occupies an essential place in our scheme of things, for it quantifies reality just as anything static quantifies the dynamic. We are implying, of course, that the real is dynamic. Appearance, then, may be regarded as a state or observable property of reality.

Likewise, the relation between quantity and quality. The

first is static and the second is dynamic. The first is a part or property of the second. Experience has taught us that whenever we attempt to make a qualitative anlysis of anything we inevitably find ourselves dealing with quantities. Nevertheless, these quantities are quantities of something, and of something aside from other quantities, namely, quality. In other words, quantities are the static aspects of qualities.

In a similar fashion the finite is the quantitative aspect of the infinite. Here, again, the former is by definition static, absolute, arbitrary; the latter is by definition dynamic —changing—relative. Expressed in different language things finite are the states, elements, structures or contents of things infinite. The finite implies the infinite just as a quantity implies a quality or just as the static implies the dynamic.

The same might be said for knowledge and knowing, matter and motion, terms and relations and many other such pairs.

The reason for all of this does not seem difficult to find. In the first place, thinking is always directed toward analysis or synthesis. We analyze only those objects or situations which are constituted of parts and which exist somehow in the form of states. Neither do we find ourselves able to synthesize without using parts, elements, or units which we can put together. The thought processes of analysis and synthesis imply structures and things static, arbitrary though the latter may be. We find it necessary to conceive things as divided into parts and we proceed with such divisions until we think we have reached our limit only to find that further analysis is possible and a reconstruction of our static concepts essential. We are forced to believe, therefore, that analysis amounts to a variable approaching a limit because it is a process which

employs arbitrary and quantitative methods of expression.

But there seems to be more to the situation than the circumstances that thinking about phenomena is impossible except as we divide them into parts. Why should the static and the dynamic be mutually dependent concepts while at the same time mutually exclusive in meaning. Evidently, to exist or to "be real" is to "take place"; reality consists of events, happenings, processes—the dynamic. Such realities are motion, life, consciousness (behavior) energy, qualities, relations, the Infinite. But motion is inconceivable without implying something that is moving; life is inconceivable unless there is something that is alive; consciousness is inconceivable without an organism which is responding; qualities are inconceivable without quantities and so on. Thus we see that while reality is activity, something aside from activity is implied and that something is the static. We conclude therefore that the dynamic is existence *per se,* and that the static is its mode of existence. Existence is inconceivable except in terms of states, parts, structures, contents and the like and presumably must have its mode before it itself would exist. In other words the static is a mode or means by which activities take place and the activity is the end.

Thus a cell, or system of cells, is the mode or fashion in which the human body exists; the existence of the human body is function or life. The element is the mode of existence of the physical universe; the sensation and image are modes of existence of consciousness; qualities exist in terms of quantities; relations exist in the form of terms; realities exist in the form of appearances; the infinite exists in terms of the finite; the relative exists in terms of the absolute.

An example will perhaps make our point clear. Water is flowing down a stream bed. The flowing is dynamic; it is an event, taking place. But the water never flows and

we presume cannot flow except *in some way;* now it dashes down over a precipice; now it sluggishly winds its way over a flat valley and so on; moreover, it flows, we say in terms of whirlings of atoms. Thus velocity, acceleration, and direction are modes of the flowing but the flowing, by implication, is something more than mere velocity and direction, *et cetera.*

From these considerations, it follows, of course, that anything static does not exist for existence is to take place. In fact, the meaning "is" does not refer to a state but to an act. It is the act which "is" and the state is merely an arbitrary but essential mode whereby the act "is." In this fashion, arbitrariness or appearance is a property without which reality would not exist.

Many perplexing problems have arisen in various disciplines of thought owing to a confusion between the two points of view represented in this parallelism between the static and dynamic or between structure and function. Since the two concepts are mutually exclusive, we find ourselves in a dilemma at once when we try to derive anything static from the dynamic or anything dynamic from the static. Anything static is by definition finite and arbitrary and as such it cannot be changed. That is, states, as states, do not change. They change through function or action. To change a state makes of it another state or another unit or another quantity. A cell grows and thereby becomes a larger cell; the instant "1" is changed it becomes "1 plus" or "1 minus," another quantity; the instant velocity is changed it becomes a different velocity. States or contents as such don't move; they do not "do anything" for by definition they are inert, inactive, impotent. They function, then, in virtue of being something aside from states, namely, processes.

The bead hypothesis in physics had its rise and fall; the

physicist is wondering what to do with this troublesome thing, matter, which is reducable to mathematical formulae; the psychologist has learned not to regard sensations, images or any other so-called mental element as a final thing; it is regarded only as a convenient tool for describing the ebb and flow of consciousness. Zeno's arrow never reached the target as long as an attempt was made to derive motion from arbitrary units of space. Any attempt to derive the dynamic from the static is an example of a variable approaching a limit. The same dilemma obtains quite as well in thinking from the dynamic to the static. The dynamic is a continuum as offset against the static which is a discontinuum. The dynamic is relative while the static is absolute.

Other troubles come from the fact that anything quantitative conceived or treated in the absence of qualitative aspects—is irrational. Quantities, abstracted from qualities are arbitrary which makes it impossible to reason from one quantity to another. Quantities as such give us no information which warrants deductions; one gets from quantities no more than he puts in by definition or finds there.

A striking example of this situation is found in the field of statistics. As such, statistics prove nothing; like all quantities and all things static they are based upon observation and everything purely empirical follows the law of chance or probability. This latter situation is but another way of saying that states and quantities are arbitrary. Conclusions, then, drawn from purely quantitative data are useful for the purposes of prediction only because they happen to work. How they work, the reasons for the predictability, can be ascertained only by resorting to the functional point of view and therefore to a consideration of qualities. We must forget that the quantitative data are quantities, states or units and regard them as functions or processes.

Results from mental tests cannot be interpreted other than from a qualitative point of view and to do this the examiner relies upon his knowledge of human nature and upon his introspective ability. There is nothing logical about the quantitative data of tests. In the first place, arbitrary units are selected, from the use of which a normal curve of distribution is obtained. Then what that normal curve means there is no way of knowing nor can the validity of the unit of measurement be demonstrated by a use of the curve of distribution since any such attempt would be thinking in a circle.

If one should observe the rising of the sun every morning for several years he would then have no rational justification for assuming that the sun would rise the next morning. The sun does not rise one morning because it rose the morning previous. To predict such an event or to derive one datum of observation from another the dynamic or qualitative is implied. One does not reason with disjointed successions of compartmentalized units, amounts or quantities alone, but by adding to these his conception of change and motion. Hence, one reasons that the sun will rise tomorrow morning by envisaging the motion of the earth with respect to the sun. The rest of the prediction is a matter habit and probability.

In theoretical psychology, a dualism has resulted from an attempt to make consciousness static, a stuff or substance, rather than action or function. As long as it was conceived that consciousness was a state of some sort there was of course involved the problem how this thing was related to the body—another state. There was also the problem of where consciousness came from and where it went; hence the logical necessity for the subconscious to complete the continuity.

On the other hand, if we regard consciousness not as something which the organism possesses, but something which he does these problems evaporate at once, for then to ask where does consciousness come from would be as unaskable a question as to inquire where the motion of the train began to move or where the motion of the train went when it stopped. In like fashion the mind-body problem disappears.

The problem of life presents the same difficulty. Both consciousness and life, regarded as activities can be conceived as real but regarded as states or quantities we are not only forced to the conclusion that they do not as such exist but we become involved either in a dualism or in the necessity of conceiving them as exclusively mechanical. That is, structurally, life is a complex of chemical-physical processes unless one prefers a dualistic conception. Once a dualist, however, the mind-body problem is duplicated in biology.

After all, then, the mind-body problem and the vitalist-mechanist controversy are not metaphysical difficulties but purely logical and can be ironed out by resorting to the logical parallelism of the static and the dynamic. "Mentalism" and "vitalism" cease to be problems when consciousness and life are regarded as functions or dynamic processes the structures of which are "physical" processes going by the name of organism.

There is an interesting corrollary of the principles set forth in this paper. As one passes from the simple to the complex, phenomena which are structures on a given level of complexity are functions on a lower level of complexity and *vice versa*. For example in chemistry sulphuric acid as such is a substance only with respect to other substances and things more complex. It derives its existence not by being a thing in itself, *i. e.*, an entity, but by means of struc-

tures of a lower order of complexity combined into a synthesis. The synthesis, the acid, is by itself alone a function, or ratio of hydrogen, sulphur and oxygen. In other words it is merely a form in which these elements exist in combination. The elements are structures and the compound is function.

In similar fashion the atom is the structure of the molecule; the molecule in turn is the structure of the compound; the compound in turn is the structure of life processes; life processes in turn are the structures of behavior; behavior phenomena are in turn the structures of social phenomena; social actions are in turn the contents of ethical data.

In psychology the problem of meaning illustrates this point rather well. Meaning, it is found, has no content of its own. Its contents are sensation and image. As such meaning is function but with respect to more complex phemomena, meaning is content. For example, sensation and image are the structures of a task-consciousness; a task-consciousness may in turn be a content of a volitional or judgment-consciousness and the volitional or judgment-consciousness may in turn be a content of a more complicated series of behavior phenomena.

In conclusion, then, we offer the suggestion that problems of mind and body vitalism and mechanism, and the subjective-objective do not offer in a last analysis a metaphysical dualism but rather a logical parallelism, the parallelism between structure and function or the static and the dynamic. No treatment of any data is complete without resorting to both points of view and the sharp distinction in meaning between the two points of view must be kept clearly in mind to avoid confusion not only in scientific but in philosophical interpretations of the truth.

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UMI

OUR "SEX COMPLEX" AND WHAT PRODUCED IT

THE genius of the present generation seems to have directed itself primarily to a study of human psychology. The two schools which have elaborated their theories into accepted sciences have two things in common—the port for which they are sailing and the shoal in which they run aground. One seeks to explain the uncertain product we call a modern human being through the study of his subconscious mind, the other through the study of human institutions. The second while less popular, is not less interesting. It assumes the "subconscious mind" to be but a product, the explanation of which lies in the forces which have produced it. "The history of social activity furnishes an infinitely more copious material to this end than could be obtained by introspection and observation of the psychical life of a single human individual. An important part of our psychical life, which for the most part does not appear in consciousness, can thus be gathered from the customs and conceptions of the people of the earth."[1] "Ethnology, and likewise ethnological jurisprudence . . . regards individual psychology, therefore, as no proper basis for science. That which we call our consciousness is in any case but an infinitesimally small portion of the totality of psychic life active within us."[1] Thus, through the idea

[1] Post, Albert Hermann, *Ethnological Jurisprudence*. Trans. by Thomas J. McCormack.

UMI

of an "individual jural sense made up of a sum total of psychical activities" [1] the student of comparative law makes the transition from the individual to the collective point of view and finds in laws and legal institutions a composite picture of the human mind.

The objective of the school of comparative law is apparently the same as that of the psycho-analyst, the method different, the cause of failure the same. It is the purpose of this article to show wherein both have reached the same impassé by making the same mistake. To the students of either school the "economic interpretation of history" would be accepted, at least partially, as the logical one. Certainly, if one attempted to substitute for the economic theory wholly a sex interpretation of history it would be repudiated as absurd. It is equally absurd to seek an explanation of individual human psychology primarily in sex motives.

The instinct of self-preservation has dominated mankind so completely that most of his psychology and all of his institutions are its pure, unadulterated product and the power of sex has been so completely subordinated to this more basic impulse that the best it can do is to hold its own. With the withdrawal of the mysticism and sanction of religion as a haven of refuge we seek in the intricacies and unanswerableness of sex a mysticism and sanction to serve as an escape from the obvious fact that most that we are and all that we have produced are the products of the instinct of self-preservation. We flatter ourselves that this sex interpretation is very daring, and therefore nearer the truth, but it is, in most instances, what Mr. Robinson calls the process of rationalizing by finding a "good" reason instead of the "real" reason.

Granting that a large part of our mental irrationalism and our institutional failures are the product of sex inver-

sions and perversions, that fact in itself is evidence that they are not the product of the sex instinct but are rather the effect of the more powerful force within us checking, curbing and diverting the force of sex at every angle. The extent to which our whole life history is saturated with a struggle with difficulties with sex is but proof that the fight is against the sex instinct rather than with it and that the answer will never be found in a study of the sex instinct itself. The objective of the instinct of self-preservation is enslavement of others, and it has succeeded; the objective of the sex instinct is freedom through others, and it has failed. But because sex adapts itself to the abstruse and the mystical it furnishes a much more congenial, flattering and "good" reason than the simple, uninvolved directness of the "real" reason—that the basic motive which governs us all is the seeking of the wherewithal we shall be fed.

The universal habit of suppression of expressions of sex is the result of the knowledge of the relative weakness of the sex instinct rather than fear of its strength. Our shifty, diffident, vascillating attitude in our sex relationships is very different from our methods of direct action when our job is threatened. Where our motive is economic we do not worry about how obvious we are. We are frankly craven, cowardly, spiteful, vindictive, treacherous or brutal, if need be, and no one ridicules the exhibition we make of ourselves for the simple reason that everyone knows it would be whistling down the wind; while ridiculing a person out of a sex interest is easily done and universally tried even when, as is usually the case, the manner in which it expresses itself is vastly more creditable to the individual. We fear sex, not as sex, but because it is the only comparable force to that which has created and maintains "the god of things as they are," and which in fact controls our psychology. We repress it and keep it in

check, not because it dominates us but because we fear it may. That is why religions, laws and moral codes are so swift and sure in their vindictiveness and spite toward the occasional individuals who demonstrate the power of sex to sweep away our allegiance to established creeds and institutions. A force which can make one willingly suffer pain in order to create another, death in order to protect another, total loss of social status in order to possess another is the greatest enemy of the force which has created an elaborate system for the purpose of protecting self against all others.

The legal analist tells us that the origin of all our institutions, which in the last analysis are a careful balancing of the relations of master and slave, are the outgrowth of the family, that organized family life is based on the subordination of a woman to the will of a man—and that this subordination is for sex purposes. The psychoanalist tells us that most of our mental derangements are the product of the interlocking psychology of family life and bondage to the hold of the parental relation on the mind of a child—and that this bondage is the product of an incestuous impulse. The involved sentimentalism through which it is argued that this basic attachment of a child for its mother has its birth in a sex impulse is an illustration of the utter absurdities to which the sex interpretation has been carried. If there is anything in this uncertain world which is certain it is that the initial attraction of the mother to the child has its basis in the instinct of self-preservation and not of sex. Granting all the involvements that affection, education and experience can heap upon it, it starts in the simple motive of seeking food where food can be found. Because the basis of institutions lies in the relations between men and women of personal psychology in the relation between mother and child, both sex relationships, we assume

that sex is the foundation of our institutions and of our psychology, and therein we go astray.

When man was a roving animal and "such a creature hurt itself (and hunting creatures are forever breaking their bones or spraining their ankles) he had no one to take care of him and he must die a horrible death." [2] All through the preceding stages of his development sex had taken care of itself without producing any perversions, psychologies or institutions. It had, perhaps, in its turn developed the mental capacity which finally achieved the grasp of the predicament that "he had no one to take care of him," and when that mental stage was reached human institutions began—in the simple psychology of a broken leg. Out of ignorance of how to deal with a consciousness of personal insufficiency in time of emergency came fear and panic; out of fear and panic came the impulse to subject some other creature to his will in order to be able to rely on something outside of himself "to take care of him"; out of that impulse has grown slavery, the family as an organization, the clan, the tribe, the city and the state. We never had a sex problem, we never had a labor problem, we never had a race problem. Throughout the history of the race we have been confronted with just one problem—the servant problem—which is considered chiefly a topic of conversation at pink teas while the truly great discourse at length on matters of sex, labor and race.

Because the nearest thing at hand to that primitive man in his first consciousness of helplessness, capable of filling his need and incapable of resisting his strength, was a woman he subjected a woman to his will, not because she was a woman, but because she was weaker and nearest at hand. He had had sex relations with the female of his kind through all his antecedent history and subordination

[2] Van Loon. *The Story of Mankind.*

of one to the other had never been a necessary part of that relationship. The operation of the sex instinct, with its inherent sense of dualness and equality, instead of being the medium of the enslavement, is the only thing that has made possible the emancipation of women from the slave status.

The two phases of human development which followed this first stage are the only ones in the history of the race where sex has been the determining factor in establishing the status of women. Out of the consciousness of personal insufficiency and need of his kind to cope with conditions man developed social organization. In the first form of organized social life, mother-right or the matriarchy and, apparently, group marriage prevails. That a partial subjection of women to men preceded is evidenced by the fact that wherever there are traces of mother-right, while the basis of all the legal institutions is the maternal relation, still women are to a greater or less degree in the position of servants. The establishment of the matriarchal system was the outgrowth of mental reactions of the sex instinct, coupled with an ignorance of facts. "Incredible as it may appear to us, there are cases in which primitive men find a difficulty in understanding that a man is responsible for the birth of a child and attribute it to the action of a spirit or an inanimate object." [3] Wherever mother-right or the matriarchy exist, the system of organization is communal. This situation relieved the fear of having "no one to take care of him" and made it possible for the conception of sex to dominate the political organization. As the sense of sex did not carry with it a consciousness of paternity, which apparently is a product of knowledge and not of instinct, the conception of reproduction centered in women. This fact, coupled with relief from

[3] Hobhouse, L. T., *Morals in Evolution.*

the economic factor through communal organization, created the matriarchal system. Then came the realization of the position of men in the perpetuation of the race, and with it the growth of father-right and the patriarchal system. "It is clear that the recognition of fatherhood must make all the difference in the position of the husband in the family." [3] "We find the transition to father-right frequently associated with the custom of couvade, which, however, it is to be understood, is clearly a recognition of the relation of the father to the newborn son. . . . Where the position of the father has long been recognized and is thoroughly established the custom disappears. Its flourishing time is at the period when the one system is beginning to give way to the other." [3] The mental processes involved furnish a highly entertaining insight into the primitive mind, to which all things are physical. In order to take upon himself the social status which the matriarchal system had attached to birth he had to simulate the physical effects of birth. These two stages mark the only periods when sex is the determining factor in political institutions. "The first condition of the paternal system is the recognition of the man's relation to his children, the second condition is that he should appropriate his wife as his own." [3] When this happened, the communal system ended, the driving force of the necessity of each individual providing for himself again became the dominant consideration and the accumulation of property began. The first property necessary to acquire was again a woman "to take care of him," and slavery and the family began in a new sense of an economic structure. So the three things which make up civilized life, slavery, property and sex, became so agglomerated in human consciousness that still we believe that conditions which slavery and property have created are the creatures of sex.

DeCoulange attempts to refute the assumption that the superior position of men was based on superior strength. He objects that the foundation of the family should be found "in the power of the father or husband. They [the exponents of the theory] make a sort of primordial institution of this power; but they do not explain how this power was established, unless it was by the superiority of strength of the husband over the wife and the father over the children. Now, we deceive ourselves sadly when we thus place force as the origin of law. We shall see further on that the authority of the husband, far from having been a first cause, was itself an effect; it was derived from religion. Superior strength, therefore, was not the principle that established the family.' And so he maintains that the power of the father grew out of his position as priest of the sacred fire. Certainly organized religion, the sacred fire, and all the involved creeds that go with it, represent a stage of development many generations beyond the era in human life where the origin of the organized family must be sought. Rather the status of priest of the family fire is the effect of the power of the father, long established, than that the power is the effect of the religious status. For organized religion has always been the means of explaining and sanctifying, and thereby firmly establishing, the various forms of master and servant that antedated the creeds created to preserve them.

The strictly patriarchal system, no doubt, "can only arise later under the influence of ancestor worship and more developed social and industrial conditions"[4] but "before any system of kinship maternal or agnatic became recognized as a principle of customary family law, there must have existed a family, or rather parent group, in which the father was protector and master of the mother and her

[4] Howard, George E., *A History of Matrimonial Institutions.*

children. This parent group is the hypothetical primordial cell of the family, brought together by sexual requirements and the need of sustenance and protection. . . . Its resemblance to the patriarchal family, though misleading, is not without significance. *For it forms the necessary stage of an evolution which in analogous manner is also passed through by property.* . . . As a general rule . . . the structureless parent group is superseded by the maternal family whose basis is mother-right, or the exclusive legal recognition of blood relationship in the female line. Only in rare cases does the patriarchal agnatic family follow immediately upon the primitive group, without prior development of mother-right; and hence, under exceptional conditions hindering the rise of the maternal system, do we find a form of the family in which, from a very early period, the house father is the source of authority, practical or legalized" [4]— in the first stage practical, in the third stage legalized. And the source of this authority, antedating the institution of the sacred fire and ancestor worship or any conscious religious conception, and the maternal system which preceded it, was force provoked by the consciousness of having "no one to take care of him." That the authority was the product of the need on the one hand or the impulse on the other for the man to take care of someone else is illogical, although the usual theory. For the power of a man, however strong, to protect his wife and children from enemies through the mere power of his strength was very slight in such a stage of natural history. Adult members of the species, male and female, had long been accustomed to doing for themselves all the protecting that was possible and the extent to which parents gave protection to their young had been taken care of through the sex instinct for thousands of years without creating any authority of one sex over the other. The need of some-

one to take care of them that these primitive ancestors of ours must have felt so keenly was not of a strength sufficient to fight with their enemies, for their most dangerous and most numerous enemies were so enormously stronger that flight and not fight was the only solution. Their need was of someone sufficiently intelligible to seek food for them when they could not seek it and to drag them into shelter from the jaws of their enemies when their own means of locomotion failed to function.

The first slight advantage that the limited measure of the first subordination gave to man—for at best his superiority in strength must have been slight where the female was a natural animal accustomed to fighting her own way—was enough to serve as the basis for all that followed, and in the matriarchal stage where conditions are the most favorable for the woman, "the drudgery of life so often falls on her while the men hunt or fight." [3] This was not because she was not entirely capable of hunting or fighting. It was because the only guarantee of protection from the consequences of hunting and fighting was to have someone bound to come to the rescue in case of necessity, and that person must be protected and sheltered from the risks of hunting and fighting, by force if need be. When the stage came where it was discovered that "food tasted better cooked" [2] it fell to the lot of the woman to cook it, not because the capacity to cook was a natural feminine monopoly, but because women had already been forced to stay in the cave to keep them from unnecessary risk of breaking their legs, and the cooking fell to the lot of the one who stayed at home. Then came the necessity of tilling the soil and that too fell to the lot of the one that stayed at home, where it remained until man ceased to be a hunting animal. And so it came about that "the drudgery of life" fell to the woman, and with her and those others on

whom the slavery status could be fastened it has remained ever since.

The rock bottom of everything in our lives is the relationship of master and servant and the whole story of human conflict is the struggle of those holding the mastery to maintain it and those held in servitude to escape it. We theorize much about "sex antagonism" and the "war between the sexes." What we are talking about is a class antagonism and a class war in which sex has been the victim but never the cause. The fact that sex tends to quell this antagonism is the only thing which has saved us from extinction long ago. Our laws and customs, based on the struggle of each individual to maintain himself and into which sex impulses have entered very little, has accentuated the cleavage between master and slave. But in our personal relationships the modifying influence of sex has succeeded in maintaining an equilibrium through forcing the sense of equality upon the very individuals most tenacious of the principle of inequality in established institutions. For it is the sex instinct which forces upon us a consciousness of the personality—hence the rights—of others, and that consciousness is the only effective enemy of the master and slave state of mind. The process is illustrated in the poem we were taught as children in which a mother, in expectation of the birth of her child, resolved that she would shut her mind to everyone and everything but her devotion to that child and was surprised to find that with its birth "all the world came trooping through."

This ameliorating power of sex is the source of all our enmity toward it, for nothing will so quickly create a panic among the truly "civilized" as the conception of any force capable of letting all the world come trooping through, for when that happens servitude ends—and service begins. Then the things we call the "drudgery of life" will be done

in a universal and genuine recognition that they constitute the highest service instead of the meanest servitude. But to the creed created mind, bound to the master and slave point of view, which needs all of its misdirected faculties in coping with the stumbling blocks in the road we travel now, there is nothing that so blinds, stupefies and terrifies as the occasional illuminating glimpses of that beacon light ahead.

An interesting case where the attitude born of the equalizing influence of sex has forced itself into law is a law of Rome at the time of Christ: "Free borne women are released from the tutela by law if they have borne three children." [5]

There are so many illustrations of the utter failure of the sex instinct to successfully compete with the instinct of self-preservation in the struggle of sex against the offspring of its more powerful adversary—those mighty infants we call slavery and the monopolistic attitude toward property. One of the most vicious consequences of that failure has been the submersion of the sense of fatherhood in the conception of authority and property. An illustration of the unnatural lengths to which this has gone is illustrated in an old legal theory. "According to the oldest law the father's power was not based upon the fact that he had begotten the child but upon his mundium [power] over the mother. The father acquired paternal power over those children only who were born to him by a wife who was subject to his mundium as a husband." [6] In theory of law his interest in the child was not as its father but as owner of the mother who produced it. And the modern man counts himself very much abused when he finds himself a victim of a case where mother and child league together to "get out of him what they can."

[5] *Gaius Commentaries.*
[6] Huebner, *History of Germanic Private Law.*

Most of our modern abnormal and simpering attitude toward sex is the product of the monastic period when sex was so completely routed in conflict with economic conditions. The precariousness of human existence produced an abnormal concentration on the hope of a future life where all would be sufficiently fed, and when the church offered a guaranty of security against the fear of "having no one to take care of him," vows of celibacy and sanctification of sex suppression came easy.

Our modern civilization has reached the climax in the power of the desire for social status, economic security, or escape from class distinctions—all products of conditions created by the instinct of self-preservation—to conquer the effects of the sex instinct. Among those who are the typical products of our heredity—the adapted—a man marries the woman best equipped to advance his social and financial interests, a woman marries the man best qualified to maintain her in the financial and social circle she has achieved or to which she aspires. Among those who are the typical product of the protest against that heredity, the ever-increasing army of women who do not marry, are the unadapted with whom the slave status sits least amiably and who believe they can escape its stigma more effectively outside of marriage than within it. Here, again, sex is discarded on economic grounds just as soon as economic conditions make it possible for women of this type to maintain themselves outside of marriage. When we become aware that the rearing of children jeopardizes our social or financial standing or our ability to maintain ourselves in the struggle, all the force of the instinct toward perpetuation of the species is powerless against the greater force of the instinct of self-preservation and the whole purpose of sex is thwarted as a matter of course.

And then we seek to explain the consequences of such conditions through an analysis of sex. The fact that most human phenomena has been explained on the basis of sex ever since philosophy began does not prove it to be the correct explanation. It is rather our most effective form of defense—the historic case of "rationalizing." With all our artificiality the only defense that will satisfy is that a thing is "natural" and sex happens to be the phase of nature which appeals most to our imagination. If we can ascribe our institutions to it we have the most complete barricade against ourselves. A delightfully absurd illustration of the extent to which we can rationalize in attempting to prove to ourselves that the institutions we like are natural is perpetrated by one of the students of comparative law. "Broadly, the family may have been said to have gone through three stages of development. In the first form, the natural family, by which I mean, husband, wife and children is not yet complete. . . . In the second form of marriage the natural family is complete and the husband is the head, but it is completed at the cost of the greater subjection of the wife, who in passing into the husband's family merges her personality in his, often almost like a slave." [3] In order to justify and perpetuate what I like, I must prove it to be natural, therefore, what I like is natural though it admittedly took generations of artificial conditions to produce it. Granting the condition described is the logical consequence of natural fears, it is not the "natural family." When the plea of the natural fails us we sanctify antiquity above all else and immortalize the obsolete as a means of justifying what obsolete conditions have produced.

The process of rationalizing class distinctions based on sex by a sex interpretation is ingrained in every thought of our lives. When we speak of men we mean humanity,

when we speak of women we mean a group. A visiting foreigner recently in the United States writes in criticism of us that we are oversexed; that wherever you turn you hear women discussed, that our newspapers and magazines are full of pictures of women and that "woman means sex." No intelligent mind, other than through a process of rationalizing, can talk about women meaning sex. No mind can conceive of sex but as something dual. Where there are not two sexes there is no sex. What he meant is that woman means a class and his European mind rebels at the extent to which American women have graduated out of a class into humanity. The only process by which a human being can be made not a human being is to make him—or her—a slave. The thing which has dehumanized our conception of womanhood is not her sex but her slave status. Those of us who are the most alert fall into the same type of phraseology. J. H. Robinson in *The Mind in the Making* tells us that "the philosophers do not seem to have speculated on sex, although there was evidently some talk in Athens of women's rights." The history of "women's rights" has no more to do with sex than the history of the laboring classes or of races held in slavery—each is the history of a class trying to free itself from bondage and has no relation to sex. But as the bondage based on sex was the first, it is the deepest rooted in our "subconscious minds" and will be the last to yield; since it is the oldest it is the most sanctified and furnishes the last "holy ground" in which the modern psychologist finds a refuge from facing facts and the modern business man a safe guarantee of personal service when laboring men go on strike and negroes quote the 13th amendment.

A third interpretation of human psychology has been evolved which would explain all human nature on the basis of our gland secretions. Here, too, an inviolable law of

sex has been found to be the reason for the relative status of men and women. The exponent of it sees in the isolation of women only a sex motive. "Acting upon their theories as to the nature and function of sex, men have, *ever since the passing of the primeval matriarchates,* segregated women, equalized them, worshipped them or enslaved them. Opinions have varied from ancient national aphorisms to the effect that women have no souls to the most ultramodern utterances of the biologist-publicist that the differences between men and women are the differences between two species." He would have us believe as a matter of biological science that "submissiveness" in woman is an inherent quality of her essential female chemical constituency; that woman is basically more sex conscious than man because of her gland secretions. He makes no reference in explanation of her sex consciousness to the overemphasis on her sex which permeates every hour of her education and experience—an emphasis for the purpose of perpetuating class distinctions rather than sex distinctions, since the latter perpetuate themselves without need of education. A temporary flash of light provokes the observation that "thus a masculine master has coined the immortal phrase, the Eternal Feminine, and in a matriarchate we should undoubtedly hear of the Eternal Masculine." But in his "submissive women" he seems to see no relation to his conclusion that "the natural effect of slavery has been a selection of two sorts of individuals along the lines of the survival of the adapted. It has tended to perpetuate in the breed the qualities of the strong which would make them stronger and certain qualities in the weak which would increase their weakness. . . . Slavery appeared as an invention of the would-be-free. It was a brilliant flash of genius of the seeker after freedom. However, it became a boomer-

ang." And it was its affiliation with sex which made the boomerang hit home.

We build theories based on the assumption of our enslavement to sex when the difficulty is our enslavement of sex. Our ailment is a slavery complex, not a sex complex. That which has made us slaves is not sex but slavery which has twisted sex to its purposes. No one, whatever his status has escaped, for so long as sex involved slavery every man's heredity, whatever his rank, was half slave; and the master who is a slave to his fear of enslavement is more completely a slave than those he enslaves. Our only possible escape from slavery lies in basing our opportunities for freedom, not on our success in enslaving those who do the "drudgery of life," but on the extent to which we do those things which must be done before any of us can be free. What we need is to free sex from slavery complex which has enthralled it, learn the physiological laws necessary to correct the mechanical imperfections which that thralldom has produced, and sex psychology will take care of itself. Then we will cease to argue that the purpose of life is sex and be willing to admit that the purpose of sex is life.

All the record that lies behind us is the product of the inevitable ignorance of a dimly dawning intelligence. Out of that record we have learned enough to have dissipated the ignorance, in some measure, and to know that it is perfectly possible to free man from the fear of having no one to take care of him without necessitating the enslavement of any other human being. Until that is done, the enslavement will go on for there is no force or combination of forces that knowledge or science can discover that can cope with that basic, driving power in all human beings. When we have freed him from the fear of his own need and the

fear of enslavement to the needs of others, the slavery complex will gradually disappear back into the primeval darkness which gave it birth, and we can quit worrying about what sex has done to us and see what it might do to us if we gave it a chance.

MARGARET WINFIELD STEWART.

THE PRINCIPLE OF ALTERNATION[1]

WHEN one sets himself to the task of such a paper as this, he may legitimately flatter himself that his mind is in possession of a more or less coherent and comprehensible thought. Vigorously, and with high hope, he sets about the piecemeal transplanting of this thought to a visible, temporal existence. In the bald patois which a philosopher might be expected to eschew, "he thinks he can write down his idea."

Sentences flow at first fluently and accurately enough. But the idea is a spaceless, timeless thing in a spaceless, timeless, unstrenuous depth of him. To seek to achieve its corporification in an energetic universe of minutes and matter is a parlous venture. He loops phrases together; becomes largely interested in the irrelevant mechanics of his task. What was an instantaneous whole, he must reconstruct painfully, a fragment at a time. What he builds is at best a mosaic of obstinate, arbitrary units which conform, on the whole, only approximately to his design; and he is in endless danger lest he become exclusively occupied with his materials—dallying with more facile but purposeless juxtapositions.

His pen drags; he gropes for expression, and suddenly, if he is honest in his efforts, he recognizes how barren his

[1] Professor William Ernest Hocking has developed the theory of the principle of alternation in his *Meaning of God in Human Experience*. We wish, in this essay, to interpret and apply this principle.

UMI

present situation is of "inspiration"— how far he has left his thought, engrossed as he is in merely thus elaborating and extending the word-patterns he has already made. Appalled, he must abandon what he has wrought and revert to the Plan; begin again with a fresh glimpse of the Reality whereof he writes. To adopt an atrocious simile, his paragraphs overlap like the descending shingles of a roof, the bottom of each continually diverging from the proper plane, and corrected, if the purpose is to be served at all, by the next shingle's new beginning; or somewhat as a man finds his way diagonally across a city perforce by carefully tacking from block to irregular block—painfully re-orienting himself at each corner—at right angles he does not like but which are thrust upon him by the exigencies of a stubborn environment.

Some such a narrow oscillation as this exemplifies well enough the Principle of Alternation—that great cycle whereby mens' minds seek to maintain in this life, upon the one hand, the practical productivity of an energetic earthly freedom, and, upon the other, their human integrity. It is the process by which all mortal tasks are accomplished.

From brief seconds of synthesis, of original insight; from holy books; vaguely from the words of elders, we glimpse a vast Worth and Purpose of life—the Whole of "past, present, and future" as we inveterately describe it —an unformulated Absolute. Generally, this mass is ill conceived of. We think of it, if we think of it, distantly and symbolically. We are content with the tacit assumption of its far, vast security. It is the background which gives worth and meaning to what we do and are. In it are the roots of our being. It is We.

But man's mind is an anomaly, a frontier where this timeless infinite meets the clocked clutter of temporal things. It is only by maintaining this precarious, para-

doxical position that he can be man—and activity is at once his life and his death. To *move,* for living creatures, is to *be.* To still the stream of consciousness is instantly to destroy it; to cease from material endeavors is ultimately to impoverish the mind by closing the only avenues through which it can be furnished. Yet, to *act* in time and space is to abdicate that high position which is the peculiar prerogative of mind. In moving we become "motors' in a mechanism. Something deep and absolute perhaps gives us the initial impulse to effort—but in the world of material vicissitudes which that impetus encounters we may carom incalculably.

The inexorable tragedy of it—part perhaps of the essential "depravity of man"— lies in this fact that our Absolute cries out to be put to earthly use, our God demands incarnation—yet in employing it or bringing it down to earth, we inevitably belie it, or lose it.

Ineradicable in man's soul is a primal conviction that the Universe has a meaning, and that he himself has a Task to perform in it, a task of infinite importance. There is in him an urge to construction—and some dim apprehension of the great plan of which his work is a part. He possesses a purpose, and a strange zeal.

But our world of eighty-three elements and four dimensions is an inhospitable workshop for disembodied Ideas. The obstinate impact of time and things finds our purposes distressfully pliant and mutable. We must fight the devil with fire, adopt material tools to make our marks on a material world, organize our efforts in crass cohorts fit to cope on equal terms with our environment. And every such compromise is a falsification of our timeless Purpose, until it may be lost altogether in the zest with which we maneuver our materials—as a baby plays elaborately and forgetfully with his blocks.

We feel that we must build our good, vaguely modelling it after what vision of the Absolute Good we may have, but in the blind ardor of the immediate enterprise we are all too sure to mistake our scaffolding for the structure itself —nailing to it a succession of incongruous planks, so that, standing on each in turn, we build ever higher and more askew. By acting upon our empirically necessary "rules of thumb," we grace them with a certain dignity—sanction —permanence. They smugly take their places among the Laws of Life. Once having granted them some respect for the sake of the part-purposes of our terrestrial undertakings, we are unable to distinguish them from our true aims. Our error grows geometrically.

Never were the non-mystical majority so noisily successful in pursuing their partial ends as they have been during the last century and a half. There can be no doubt as to the chosen philosophical purlieus of the masses, in this or in any age. The man on the street is an execrable mystic. His is always a world of valiant partial purposes, strident artificial ends.

His first demand is for "practicality"— and his whole life is essentially impractical, weakly and tenuously theoretical. His first question is, "What's the use of the thing?" and that is the last question he could answer for his own entire scheme of things, though that scheme is designedly of the sort which *demands* a "use." He has forgotten the original value and the original purpose, and his partial empirical values and purposes, which were mere means and tools of expediency, he mistakes and defends as the ends and purpose and value of life with a blatancy which would compensate for his illogical superficiality.

He appraises a thing only as it reacts upon something else—and so he can never evaluate the Whole. He can

recognize a thing only by a definition, which is a limitation —to which the great Truth is not amenable.

His word is a hopeless plurality. He picks a particular "job" out of an infinite bin—and drops it in another infinite bin. It matters little whether he has successfully wrought upon it or not. His accomplishment in any event is infinitesimal. He is carrying water in a sieve—bailing the boundless sea with a child's bucket—and the water is already trickling back across the beach. He must conquer detail by detail—and has himself declared the details numberless and essentially invincible.

A thing is a thing to him—and nothing can exemplify or reflect a vista of the Whole. His objects are standardized, classified, labelled. He is impotent to pierce to a possibly reconciling unity or individuality. Because he beholds only artificially isolated bits of experience, he can only brand them harshly as bad or good—as a malignly microscopic eye might see only the green and violet granules of a Lumiere plate and miss the whole mellow glory of the autochrome.

His whole system demands ends to-be-attained—and since his definition of an end—a purpose—is something in-the-future, he is automatically forbidden to attain it. He is self-doomed to live in a present to which he denies the power of satisfying him.

There is induced, moreover, in our world of parts a false circulation of cause and effect, reasons and results, that invests it with an appearance of rational permanence. Our partial pursuits and attainments justify one another, in sterile cycles which only some degree of deeper mysticism can find pregnable. The "tired business man"—America's patron martyr!—revolves pitiably and perpetually in his vicious orbit—making more money that he may do more business, doing more business that he may make more

money—striving to lift himself by his own bootstraps—to manufacture by his persistent ardor that "worth of life" which inexorably evades him, till he finally dies, disgruntled, in the harness—or adopts the inadequate subterfuge of a "hobby"— or suicide.

On a larger scale, our temporal systems of ethics and actions blandly exchange credentials and perpetuate each other *ad infinitum.* A militaristic state generates a militaristic moral code which justifies an intensified militarism that in its turn will endue the moral code with new and more belligerent virtues. In such hopeless mental merry-go-rounds spin always the vast unconscious majority of human minds. The elephant stands on the tortoise and the tortoise hangs on to the elephant, to paraphrase the ancient puzzler, and it is appallingly impossible, without bursting bounds and viewing the couple from the outside, in mystic religious fashion, to point out the discrepancy in so neat a system.

But so long as the material systems of his world are running smoothly—and as a rule they maintain themselves with an uncanny exactitude and sufficiency—the active "average man" has nothing but the most outspoken scorn for the non-conforming philosopher. It is the inertia of the world, the flesh, and the devil rebelling against the disconcerting disturbance of their gyroscopic equilibrium.

It is vastly easier to be a cog in a machine; and the first and most crushing indictment which mechanical minds can bring against their disturber is that he is not a cog. He isn't flipping around and around with the rest of the clockwork—by their code he is already condemned and his criticism vitiated. "Useless person," they say; "worthless; never get anywhere . . . buzz . . . buzz."

And so far are they wrong, that he is really the only man even inquiring after a destination; he is the only person with anywhere to "get." He is outside the machine—

and he may make execrated attempts at liberating his fellows—or become a cynical engineer oiling the wheels for his own benefit (as a Caesar, for instance, might well be something of a mystic). His efforts are so far from being worthless that they and their object are the only Value, the summation of the total worth of things, in whose behoof the human gears are grinding.

"Morbid," men hugging their little forge fires diagnose the pronouncements of genius that sees the stars. But the mystic-genius alone is hale and whole, in the open spaces, while they dwell moribund indeed in the very antechambers of death.

But it is not the only sin of our mundane mechanics that they confuse purposes and values, the true with the false. They do so only by confusing and stultifying the personality at their core. We and our fellows act in a world of things. In his activity among objects my brother becomes to me little other than an object; I am just another such obstinate and energetic detail to him—and we both obediently live up to the parts thus assigned to us.

To live together in time we must be able reasonably to predict the actions of one another. Our souls must become simplified, standardized, deliberately dwarfed in order that our fellows may with assurance treat us as the conventional counters whereby their temporal commerce is transacted. If I step on a mans' toes in the street car, I know what he will say and do, for I know that his response will issue from a soul that has become a docile article of commerce—not from the depths of an infinite Self, rooted in eternity. He has set himself long ago to the human task of shaping material things—and they have shaped him. His mind has become merely a more agile reagent in a world-brew of particulars whose reciprocal reactions are so neat that they seem to require no further justification. He

and I have become conventionalized figures in a world of symbols—till it is as though a set of chessmen put themselves to play a wild game of their own accord.

We manufacture ourselves—and the shape we assume is after the pattern afforded by the fortuitous impacts of the world. We conform; we strike a mean with other men and the material world, become interlocking, artificial entities, standardized parts—little brothers to that "Universal Car," easily replaceable in exact duplicate.

The infinite depths of selfhood are dutifully glazed over, hidden from the world, forgotten, so that even to himself a man becomes a shallow and obvious thing, his motives to be calculated like the motions of a linotype machine. Our psychologists may speak placidly of the "complexity" of his choices, as though they comprised only a rather more than usually intricate machinery. He himself affects a naïve philosophical surprise whenever, despite the sternly repressive and regulative effect of our social reactions, there appears in his soul some original impulse which is not at once resoluble into or explicable by the most obvious elemental components recognized in his strenuous daily activity. He has so whittled down his soul to make a pawn of himself that his residual possibilities are easily calculated.

On the one hand, he relegates his mystic and infinite Self to a vast distance, till he himself forgets the way to it, maintaining in that depth a desperate aloofness and isolation; on the other hand, he and all of us *things* communicate glibly enough in a shallow foreground, brilliant with a colorless artificial light—as though a little jutting platform whereon we strut and play dutifully our petty truncated parts.

The tininess of the stage may make easy some superficial predictions—but only the mystic possesses a magic com-

prehension of what lies back in the shadow, the secret Selfhood of humanity that warped and enfeebled and mutilated in all its manifestations still struggles through the turbid surface and proclaims weakly a kinship deeper than the ephemeral conformities of the market-place. Only he can maintain the liaison of humanity. By his comprehension of this fundamental sameness of the ultimate Object upon which our souls converge, he affords a basis for a social solidarity eventually more stable and real than the quick chemical cohesion of the city ways.

He who would find his life will lose it; he who loses his life (and practical liberty) will find it. A soul stands instantaneously alone at its Absolute—all the ways of time and space diverge around it, the sphere for its conscious activity—and it cries out to employ that freedom of effort which it possesses. It chooses; and its freedom incontinently vanishes. It plunges into a strident quest along inevitable paths in a compassless labyrinth of corridors. Only by winning back to its Absolute may it find the crossroads again. There alone is freedom, a freedom which disappears as soon as it is asserted. The soul is at liberty only to gain that effortless center of existence, or to abandon it.

In choosing, I limit myself. I abbreviate and maim my soul. I become less than whole, and less than real. It is my right, my "duty" perhaps, to manipulate the matter of earth; but in doing so I largely degrade myself to a physico-chemical, simplified thing of four measureable dimensions. In narrowing my horizons—which is the first prerequisite to any partial accomplishment—I narrow myself.

The recurrence to that final point of departure, the recovery of original worth, is the essential religious experience; in its deepest and purest form a discovery and attainment of God. This is the greatest or the summation of

those vital alternations whose fact and necessity are to be recognized on all levels of experience. If God indeed be nothing more he is at least and finally that absolute point definitely outside the vain treadmill of existence which orients and gives worth to its movement.

Doubt in some form is the beginning of religious insight —even though it be doubt of pretended religion itself. The cynic, the skeptic, the materialist, the atheist, it may be, are nearer to this God than many of the most persistently pious of his avowed servitors. A denial of worth or purpose is at least an earnest of the quest of God, and may bear more conviction than the most frenzied asseverations. It is the "romanticism" of the world of workaday which finds it so easy to believe in a God. So long as Deity is by definition infinitely distant he can hardly be denied. The atheist is in his own way demanding a God evident in experience whose worth illumines the present moment—though his God "come up missing!"

There are indeed grades and degrees of our depravity, and of the "mysticism" which corrects it. Even for our practical pursuits a recurrent doubt must have its place. We must somehow cling or continually revert to the whole which gives value and meaning to the work of the moment. To assure our most fragmentary gains we must return and appeal to *some* greater Unity—a relative Whole. The smoke and sweat of the workshop obscure even the more obvious aims of work. One cannot build even orange boxes unless from moment to moment he loosens grip on hammer and nails and seeks again, passively, the Idea.

On a rather higher level, the rich man who reproves the meticulously elegant idleness of his friends, even though it be only to urge them to play the stock market, is to that extent a mystic voice crying in the wilderness. A man who decries an aristocracy of birth, if only to extoll a timoc-

racy or a doctrine of the right of might, may well be in possession of some such flash of insight into truer values. He has at least cracked a surface of normally impregnable varnish.

Most men have moments of such mystic vision, when a vista of the "wildness and the pang of life" breaks through their little cordons of the practical, complacent policemen of palatial things, and makes them doubt, terribly, the worth of what they do.

For if it is natural for all men to lose themselves in the merry-go-round of things, it is equally instinctive in them to revolt, now and again; and the seeds of discontent are generally present. Few there are so abandoned as to consider themselves merely corpuscles in the "body politic." "I am different" is the epitome of the Self's insistence. Somehow, everyone clings desperately to that tiny stifled kernel of individuality which he thus vaguely apprehends somewhere in him. Each holds some fragment of judgment in reserve—if only that in the hour when his "practical" goods are all awry, it may be a partial consolation to doubt ephemerally their worth. To that extent most men are mystics— and to this germ of dissent the great Prophet must appeal. It is the entering wedge of doubt—and reflection.

The artist with his cult of beauty is recalling men to a more genuine and original appreciation of a self-sufficing Good. The romantic lover sometimes achieves a more magic synthesis. He finds an individuality in which criticism is absorbed harmlessly, its components cancelling one another to nullity; and he has found something able to embrace a vast and immediate Meaning and indubitable Value.

The true mystic seeks by a harder path, with a quaint complex of self-abnegation and infinite ambition, the sum

and center of all these partial values. By a strenuous effort throwing off and casting behind him the strenuousness of the agora, freeing his mind of all partial "practical" considerations and connections, reducing his whole being to a white-lit, expectant, "passionate dispassion," he awaits the effortless advent of a knowledge of the whole of things —the timeless realization *in toto* of his Universe, his Absolute.

He has accomplished an organic union of all experience, and henceforth partial interests are redeemed and made real—become spots where eyes once lit with the love of God can forever see the Worth of Life shining through. The paltry mundane vortices which dizzied and paralyzed us are broken up and forgotten, in preparation for new things.

In such moments of understanding we may attain that formless Total of life which is pregnant with all form—the basic clay from which the world's particulars are modeled. We may break the glazed vessels of our lives, and in a sense truer and greater than the poet knew, remold them nearer the heart's desire.

The mystic finds the Whole-Idea—the "concrete universal"— absolute value immanent in the totality of things. He sees at once present corporeality illumined by an ultimate and indisputable worth, and the worth-of-life clothed, made comprehensible, and accessible. Consciously and deliberately he has in worship sought for and found that self-sufficient *raison de vivre* which one glimpses sporadically through the windows of other effortless appreciations. He falls in love with the Universe, with a passion in which the artificial criticisms of practical life are vitiated, and the distinctions of good and evil merge to meaninglessness.

The mystic has fallen in love with God.

But he is certain to lose more even than his conquest has gained for him if he expects peacefully to possess and abide in this promised land. To live exclusively with the Absolute is as fatal as is the false strenuosity of the market-place—results in an ineffable contentlessness of soul that is sterile and useless even to itself. Neither phase of the alternation can maintain itself without the other.

The world has few less admirable spectacles to offer than that of those useless and timorous quasi-mystics who pop like daring rabbits out of their Wholes—wrinkle their noses to find themselves instantly and inevitably astray—and lollop back to shelter. Even the Whole is a gaunt and profitless thing without the booty won in just such excursions, bold and far into the world of things. The mind can be nothing more than its furniture—and its furnishings are acquired only by existence and endeavor in time and space. The Whole-Idea is a timeless, spaceless summation of temporal and spatial vicissitudes. It is but an empty, echoing shell, a delusive vacant vastness, save as it becomes a synthesis of multiform accretions from a rich and strenuous experience.

The great mystics have been unafraid to explode volcanic broadsides of earthly energy, when occasion demanded. Their love and knowledge of God were the obverse, as it were, of the greatness of their love and knowledge of the world. Great, shattering and shaping strokes of temporal polity had always their origin in a vision of the Infinite; but this vision of the infinite was gained only by an infinite interest in the finite.

To rest at either extreme is to dwarf the soul. The life and being of man *is* just such an alternation between the two—they are somehow strangely the same thing. To attend exclusively to the whole is to attend to an emptiness; to attend altogether to the parts is to be like aimless children

playing with the bricks with which the builder might make his house. Only by such a continual alternation can the world of mankind advance or exist; man moves by great blundering strides, now a momentary vision of the Whole to give worth and direction to the minute, now a new rush of particular enthusiasm to redeem the stagnation of the mystic Total. The vastness of this arc is the measure of our humanity—and our Divinity.

The new renaissance of the last century and a half had its conception in a certain new and deeper insight—a sudden openig of vistas—that inspired the world to a vigorous and incredibly successful assault on a practical world of particular things. Perhaps the vision was a false one. At any rate, it has disintegrated to a plurality of partial loyalties, and the ranks are broken, dispirited, confused. The seamless banner that claimed universal allegiance has been rent and flaps its scattered remnants from ragged squadrons:

"And we are here as on a darkling plain,
Swept with confused alarms of struggle and flight,
Where ignorant armies clash by night."

Even now the pendulum is poised and tremulous for the back-swing. The world of things is weary of itself and ripe for a new synthesis—or disaster. Everywhere is unrest and disgust with the details that only yesterday absorbed men's interest so sufficiently. Lacunae are gaping in the endless chains of sanction and reciprocal sanction. The auto-hypnosis of humanity is losing its spell.

But our passionate excursions into the realm of particulars have not been in vain. They have furnished us the impetus for a further sweep in the reverse direction. The Whole, when we seek it, will be greater and richer for this

earnest gleaning—and there are men today who are finding it so.

The cramped Absolute of the Mediaeval was a sterile thing. Science today has made us as impatient of the contentless Ineffable as of the quaint Craftsman who sat just behind the crystal dome of the sky, and wrapped babies up in cabbages for delivery. We have learned to think in terms of billions of years and millions of light-years—and the ten-thousandth fraction of the hydrogen atom. And this bigness, merely physical though it may have been in its inception, is already being mirrored in the new profundity of the vision of God.

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THE PSYCHIC NATURE

A New-Old Religion

TO those who newly accept the facts and conclusions contained in the two preceding sections of this paper, there will come a necessity for a revision of their religious belief; there will arise a need for a new statement of the meaning and the goal of life. But this new religion will be no different in essence from all other religions, which are but the results of an irresistible urge to seek a cause for every effect, and for the cause of life itself. As Max Müller says:

> "Wherever there is human life there is religion; wherever there is religion the question whence it came cannot be suppressed."

In the early days, this need was easily satisfied by fantastical notions, but with every advance in scientific attainment there has arisen a necessity for a revision of beliefs to make them accord with ascertained facts, and the process still continues. Bryan is right; an acceptance of evolution as true will relegates to the region of childish notions the larger part of the dogmatic theology of the Christian Church, which is so dear to those who have been trained into its belief.

Patterns are formed only through the stimulation of the senses by concrete objects, hence they reflect objectivities. But congruous to those patterns are emotions from the great sympathetic system, and these enter in and become

part and parcel of the reflection in the consciousness. A person hearing a strain of music, or witnessing a humanitarian action, does not discriminate between the two totally different causes of his response, although there is indubitable proof of that difference in the reactions of different individuals; one well supplied with certain emotional factors may manifest joy, even to tears, under such stimulation, while one lacking in such factors, may manifest the utmost indifference. The latter, however, may be as deeply moved by other sensory patterns, which stir up other emotional factors, with which one happens to be plentifully supplied.

The sympathetic system in the human organism is a thing apart from the intellect, the sensory patterns, but willy-nilly, its factors govern the deepmost feelings and influences all reactions. Emotions create no patterns, they simply tincture existing ones. No one can picture hope, fear, joy, wonder, or any one of those enumerated by Spinoza, however vividly the concrete outward manifestation of them may be represented in words, statuary, painting, or in the faces and actions of our fellow creatures.

Science and dogmatics but stimulate the sensory system by presenting concrete facts or symbols; all clarifying of these serves to clear the patterns of erroneous impressions thus set up or received through the unreliable senses, but the general emotional content is not changed. The only result of improvement in the patterns is to prevent the admixture of incongruous emotional factors into the combined reflection that enters the consciousness. The purifying of the sensory patterns works to harmonize the factors in our dualistic system, enabling man to progress out of the fogs of superstition and to apprehend more clearly his place and mission in life.

What patterns, then, will be stirred into activity by the stimulation of the auditory nerves from the vibrations caused by the utterance of the word "religion," or from the

reaction of the optical nerves from seeing it in print or script?

Each and every person will form the pattern that heredity, training, and experience have conspired to produce. Among these factors there is none more controlling than that of a seeming necessity to conform to the observed reactions of those among whom we live, that inner urge to be what others expect us to be. The weight of conventions and the controlling impulse to obtain the approval of our neighbors are large elements entering into the constitution of our patterns; the religious pattern is almost, if not quite, dominated by these influences.

A Confucian, Shintoist, or Taoist, can no more avoid having patterns tinged with "Way of Heaven" and worship of his ancestors, which are current in his surroundings, than he can avoid using his native language. Even when converted to Buddhism or Christianity the old patterns will remain but slightly encrusted with the new ideals. It is the same with the Buddhists, who are taught to banish concrete images and attend to reflections of almost purely emotional content, which creates the feeling that there is no being, that it is all becoming. And that suppression of all cravings for the gratification of the senses and the desire for a future individual life, is the way to achieve happiness. It is so with the Mohammedan whose patterns are formed from a contemplation of the words and life of their prophet Mohammed. It is so with the followers of all established religions, but underneath all the various cults, and common to them all, is the fundamental feeling that there is something superior to material, physical nature.

"We may say, then, that the development of religion follows and is determined by a sense of need . . . no savage peoples have ever been found with a highly developed religion. The religion they possess is suited to their needs and is on the level of their advancement in culture and outlook on life. An intelligent people demand a religion suited to

their wants or else it will gradually become outgrown." "And now again Christianity finds herself in the midst of an intellectual crisis. It has been in progress for a half century and more and no one as yet quite sees the way out. The doctrine of evolution, applied to social and historical sciences as well as to inanimate nature, and the methods of literary and historical criticism, whose sweep nothing escapes, have brought the intellect of the world face to face with the necessity of a new interpretation. It cannot be escaped. Should Christianity fail to use the opportunity to make a reappraisal of its documents and its doctrines, its day would have passed." "One of the deplorable results of the Reformation was the emphasis placed on orthodoxy. Men were to be saved by believing, but belief was defined, not in the Pauline sense of trust, but as an act of the intellect, accepting a set of propositions as true."—(E. D. Soper in the *Religions of Mankind.*)

It is rather singular that the ordinary protestant never stops to consider the significant fact that his particular set of proposiions has secured the sanction of only one-tenth[1] of those professing religion, but it is understandable when we take note of the immediate egotism engendered by his religious training for a personal salvation.

There is in the human make-up an irrepressible desire to see beyond the finite; to know something of the infinite. A man climbing the mountain to see that which is beyond, finds higher hills beyond which lie other vistas, and when he has again climbed he still finds that there are fields beyond his ken; thus he comes to a realization that no matter

[1] Census of Religions:

Number	Designation	Per Cent of Whole
20,512,000	Shintoists	1.2
135,161,000	Buddhists	8.1
136,324,000	Animists	8.2
210,000,000	Mohammedans	12.6
210,400,000	Hinduists	12.6
301,155,000	Confucians-Taoists	18.1
74,000,000	Hebrewists	4.4
273,500,000	Roman Catholics	16.4
121,801,000	Heterodox Catholics	7.3
170,900,000	Protestants	10.2

how high he may climb he can reach no end. It is thus that we must regard the infinite as an abstraction without form or content, yet there remains that irresistable urge to extend the known into the unknown. This reaching forward and upward, of which the beginnings are found in the lowest living forms, is imbedded in the nature of man. When scientific attainment permits of a logical explanation of this urge there will be an immediate spurt forward toward a higher conception of the universe and a better understanding of the obligations imposed upon life. Only as men rise to this loftier level of emotional reaction do they appreciate and understand the deathless utterances that lie in the world's literature.

Plotinus, one of the most noted of the Neoplatonic school, writing of the infinite, says:

"You ask me how we can know the infinite? I answer, not by reason. It is the object of reason to distinguish and define. The Infinite, therefore, cannot be ranked among its objects. You can only apprehend the Infinite by a faculty superior to reason, by entering into a state in which you are your finite self no longer, in which the Divine Essence is communicated to you. It is liberation of your mind from its finite anxieties. Like can only apprehend like. In the reduction of your soul to its simplest self, its divine essence, you realize this Union, nay this Identity."

There is something in the utterances of great men, whether in literature or works of art that baffles analysis, while it creates emotions of which the consciousness is unaware; emotions that are beyond the pale of any formal science. Poets and romancers, when their works endure, have been the creators of religion, for they have appealed to the emotions that compose the real essence of man. May it not be that this essence is one with the Supreme Essence of the universe? It is through romance, of which the Bibles of the world are the highest exponents, that man has come along his toilsome way from the brute and from savagery.

No progress results from a mere recital of the actualities that have developed from the sordid, mean, trivial manifestations of the imperfect, discordant, and blundering instrument in human form. Realism in literature can portray only the sad mess that the human instrument makes of life; an instrument that has not yet outgrown its inheritances from the beasts of the field, the birds of the air, the fish of the sea, and the reptiles that crawl. Only here and there do we find a sensory brain listening for the whisperings of that "still small voice"; to that inner essence which is more important than all else. A few there are who ignore things as they are to picture things as they ought to be; even if, now and then, these few stop to depict actualities, it is only to darken the background, the better to bring out the contrasting high lights.

It is possible to image all the great aspirations of the human race as impulses from the universal essence and to believe that they may come true in some way and at some time. Addison has expressed one of these aspirations in his lines:

> "It must be so—Plato thou reasonest well!
> Else whence this pleasing hope, this fond desire,
> This longing for immortality?
> Or whence this secret dread and inward horror,
> . . . . . .
> Of falling into naught? Why shrinks the soul
> Back on herself, and startles at destruction?
> 'Tis the divinity that stirs within us;
> 'Tis heaven itself, that points out an hereafter
> And intimates eternity to man."

May not this be a whisper of the incarnate spirit, presaging such a sublimation of matter as to evolve a perfect instrument for the manifestations of the attributes of the Supreme Essence, no longer needing the makeshift of "marriage and the giving in marriage" to perpetuate itself.

When the "seeking after God" will be ended in the realization that:

> "All are but parts of one stupendous whole
> Whose body nature is, and God the soul."

It is surely an incongruous mixture of patterns that throws into the consciousness the image of a God, as the creator and regulator of the spheres; the originator of the laws controlling natural forces; the keeper of the beasts of the field and the birds of the air, and yet denies to that Supreme Being the control of human organisms, nay more, that sets up a suppositious spirit or soul to take that control out of God's hands. But this is what has come out of the intellectual egotism in man, which has tinctured all of his religions and none more so than that of the Christian Hierarchy. The so-called Christian is egotistically self-centered; he is trained by his religious teachers to form dominant patterns that place emphasis upon personal salvation and eternal individuality. He whose life is absorbed by the cares of business or the attainment of superficial knowledge, at more or less infrequent occasions, particularly in church, puts his sensory patterns to sleep, when the resurgence of emotional elements makes him attend to the whisperings from within, and in this state he is ready to accept the dogmas of his preacher or the prevailing form of religion. But what a tremendous gulf separates the man who prostitutes his organism, as the hog does his, to get the most for himself out of the trough of life, and the man who cultivates the subtler elements of the emotions; who admits and makes a part of his ordinary patterns the factors of love, truth, and beauty.

When the present childish race shall have acquired more knowledge of the psychic nature; when there is a better realization of the obligations imposed upon human beings; much of the evils that now arise from imperfections in the instrument will be eliminated. As Max Müller says:

"When the soul(?) has once reached this true union with God, nay when it lives in the constant presence of God, evil becomes almost impossible. We know that most of the evil deeds to which human nature is prone, are possible in the dark only. Before the eyes of another human being, more particularly of a beloved being, they become at once impossible. How much more in the real presence of a real and really beloved God. . . . As long as there is no veil between him and God, evil thoughts, evil words, and evil deeds are simply impossible to one who feels the actual presence of God."

The conclusion of this great scholar, after an exhaustive research into all religions, is the conviction that the Supreme Essence is the moving power in all organisms; that this Essence has never abdicated Its control of human destiny; that only as we admit more of this power into our sensory patterns will we obtain a logical, satisfactory, and effective religion as a true interpretation of life and a guide to right living.

Re-reading of the words and life of Jesus Christ, with this conviction uppermost in the patterns, one will find His key-note to be: "I and my father are one." His teaching emphasizes the omnipresence of that Supreme Essence.

Can it be doubted that such a religion would enormously add to the dignity of life? Its inculcation into the patterns of the rising generation to the same degree that the creed of the Roman Catholic Church was inculcated in the middle ages, would in one generation regenerate human society and hasten the time when each one would strive to see how he best could live and best could serve.

The only difference, then, between the new religion, which is to be, and the old conceptions, is that the present uncontrolled emotions will be restrained, and guided, by fuller, wider, and more profound knowledge of the psychic nature; so that fanciful notions and superstitions, now arising through the unhindered workings of the emotions, will

be swept away; that harmonious relations between the sensory and the sympathetic systems will grow until the human organism becomes a congruity more fitted as an instrument for the promoting of life's progress toward its goal.

Religion must affect life favorably or it is worthless; to influence life, the religion must be expressed in terms that create assenting patterns, through which the whole life is controlled. To sum up and to put in concise form the following creed is tentatively submitted for thoughtful consideration.

A New Creed

We Believe, In an Essence omnipresent in the universe, which is a creative force; one that is ever recreating; the acorn to the oak, the egg to the bird, the grub to the butterfly, the human embryo to a full-fledged operating instrument. The vivifier as well as the creator of the physical universe.

That the universe was evolved to furnish forms through which this Essence could become manifest.

That the impulse of this Essence is to make all things work together for good, and, hence in the oneness of life; a single force seeking manifestation; the final goal is assumed to be the development of instruments capable of discovering all possible harmonies.

That the attributes of the Supreme Essence are wholly perfect and good. That evils arise from imperfections in the instruments; imperfections, not yet eradicated through evolution, which distort good impulses to bad ends. That selfishness is the misapplication of the impulse to conserve when applied to individual rather than to universal service; Greed; an exaggerated impulse to acquire; Sexual depravity, a perversion of the procreating impulse.

That physical forms have developed through the "trial and error" process, by which good and bad, right and wrong, are known from the effects of manifestation. All that tends toward progress, to the perfecting of instruments, is right and good, and all that hinders such development is wrong and bad. That the former are enduring and the latter are transient.

That the sympathetic (emotional) system in human beings is directly affected by the impulses from the Supreme Essence; that only as the sensory is attuned to this "still, small voice," is progress possible.

That immortality is an attribute of the Eternal Essence, not of the provisional, perishable forms through which that Essence seeks manifestation.

That true happiness comes only through a consciousness of harmonious relations with the Spirit of the Universe; of being of service to God in His development. That the greatest happiness, the noblest aspirations, the loftiest religion, consists in conscious devotion to the improvement of instruments for service to the race.

That the paramount obligation is to become better fitted to manifest the attributes of the Supreme in their purity, not only as regards the present generation, but that of generations yet to come.

That the attainment of exact knowledge is the path by which human beings can bring their intellectual state into rapport with the Immanent Presence, and bring about a harmony between the sensory and the emotional parts of their dualistic systems.

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CRITICISMS AND DISCUSSIONS

DESCARTES' METHOD AND THE REVIVAL OF INTEREST IN MATHEMATICS

NUMEROUS historical factors in the sixteenth century conspired to give renewed stimulus to reflective thinking and careful criticism not only in science and philosophy but in nearly all branches of mathematics. Important contributions were made to algebra, theory of equations, trigonometry, and coördinate geometry made its appearance.

Stevinus' publication of his work upon *Static and Hydrostatics* in 1586 opened a new era in the application of mathematics to the science of statics, which had made no progress since the time of Archimedes. The science of statics had rested upon the theory of the lever: straight lines were used in representing forces, thus reducing many theorems to geometrical propositions. Galileo, in applying mathematics in his researches on mechanics, gave to the world the foundations of the science of dynamics. Acquainted with the theories of Democritus, for Galileo change is nothing but change in the relations of "particals." The so-called, sensible qualities are subjective; while quantitative relations are the only possible characteristics. Consequently, mathematical expressions of these quantitative characteristics of objects constitute, for him, the final achievement in science.

With Stevinus' and Galileo's development of applied mathematics there gradually arose an hitherto unsurpassed success in the use of mathematics in physics. We find Guldinus using mathematics in determining the volumes and surfaces of certain solids, Wright applying mathematics in the discovery of the scale and in plotting maps, Snell, in his discovery of the law of refraction of optics, and Kepler, in determining the volume of certain vessels and the areas of certain surfaces by means of infinitesimals instead of by the long and tedious method of exhaustion, and most of all in his formulation of the three laws of planetary motion.

But the influence of mathematics upon physics also was reflected in an influence upon philosophy. In that day of methodical reflection, most philosophers, being mathematicians and physicists themselves, were very much influenced by the growth of pure mathematics and the great success of applied mathematics. "Scholasticism," now revolted against, had to lead to critical and systematic metaphysics. Consequently, there was felt a need for a new method which would put philosophy on a firm foundation.[1] As early as the sixteenth century Bruno pointed out, in his treatment of Copernican doctrine, the necessity of a rational factor for a critical elaboration of sense perception.[2] *That* rational factor was found in mathematics. "Rational science is mathematics." From this conviction,[3] Descartes supplied, as he thought to philosophy a new method which was mathematical as a foundation upon which the superstructure of systematic philosophy could be securely built. Although educated in the "Scholasticism" of the Jesuits, he came to feel that metaphysics, whose results were always being disputed, was useless for the discovery of truth.[4] The same, he thought, is true of Aristotelian logic, being a "dialectic which teaches the mode of expounding to others what we already know, or even of speaking much without judgment of what we do not know."[5] On the other hand he aimed to study the logic which teaches the right conduct of the reason with the view of discovering the truths of which we are ignorant.

After discarding "Scholastic Philosophy" and the wide and varied learning of empirical disciplines, he turned to mathematics, as the only "salvation" to satisfy his "most earnest desire to know how to distinguish the true from the false."[6] A creative mathematician

[1] That need for a method gave rise to Bacon's systematization of the current ideas in the realm of induction. Bacon thought that the failure of philosophy in the past had been due to the absence of the proper method. He, like some of his contemporaries, rejected Aristotelian logic and helped to construct a new method in order to get new facts. Because of his chief interest in the practical end of discovery, he was blind to the theoretical value of mathematics. But his failure really to understand induction as it was used by Roger Bacon, da Vinci, and others before him and by contemporaries such as Gilbert and Galileo, is inexcusable.

[2] Bruno, *Dell' Infinito, Universo Dei Mondi.* See also Windelband, *A History of Philosophy* (tr. by Tufts), New York, 1905, p. 389.

[3] *Discours de la Methode.*

[4] *Discours de la Methode* (tr. by Veitch), p. 9. Later inspired by mathematics, he reconsidered the value of the study of metaphysics.

[5] Preface to the *Principles* (tr. by Veitch), p. 183.

[6] *Discours de la Methode* (tr. by Veitch), p. 11.

himself;[7] he could not help seeing the remarkable success of applied mathematics. He probably was especially inspired by the certitude of mathematical reasoning.[8] Mathematics supplied him with the criteria of truth and the method of discovery he sought. He believed that the method of geometry and algebra, although not perfect,[9] would if modified and expanded serve as a basis for the development of the "true" method.

To the methodical principles of Bacon and Galileo, Descartes added one of great importance, i. e., that the method of *reflective induction* may be capable of producing principles of highest and absolute certainty from which, by the method of *deduction*, if introduced from time to time at the proper moment, the whole of experience can be explained. Such a method was original with Descartes and was an answer to the demand of his time for a systematic unity of knowledge.[10]

Descartes' method has been persistently misunderstood by students of the history of philosophy. A group of historians identify Descartes' method purely with deduction. One historian, for example states, Descartes would have us begin "with axioms, or principles which are self-evident, which everyone accepts who hears and understands them. From these principles as our starting-point, we deduce other propositions which logically follow from them, and which are just as certain as the former, provided that no mistake has been made in the reasoning. That is, we begin with simple propositions that are self-evident, and pass from these to more complex ones; our (Descartes') method is synthetic or deductive. This method must be applied in philosophy. We should proceed from absolutely certain first principles, from propositions which are clear and self-evident, and pass on to new and unknown truths which are equally certain."[11] While another group of historians admit that we cannot

[7] Descartes is generally considered the inventor of analytic geometry. Strangely enough, he does not claim this honor himself, nor dispute priority with Fermat. He seems to have believed the methods of analytic geometry were implicit in some of the later Greek mathematical works, as perhaps they were. However, this may be, he can, nevertheless, undoubtedly be called a creative mathematician.

[8] *Discours de la Methode* (tr. by Veitch), p. 8.

[9] *Discours de la Methode* (tr. by Veitch), p. 8.

[10] *Meditationes de Prima Philosophia* (*Resp. ed. sec. obj.*).

[11] Thilly, *History of Philosophy*, New York, 1914, p. 275. See also Cusin, *Course of the History of Modern Philosophy* (tr. by Wright), New York, 1852, V. II, pp. 90ff.; Bowen, *Modern Philosophy from Descartes to Schopenhauer and Hartmann*, Second Edition, New York, 1887, pp. 24ff.; Erdmann, *History of Philosophy* (Ed. by Muirhead), London, 1892, V. II, pp. 12-13 and p. 19.

separate Descartes as a philosopher from that of a scientist, nevertheless, when they discuss this method, they fail to understand it. They know that Descartes' method is more than deduction, beginning with self-evident truths or axioms, but they ascribe the method of deriving these fundamental principles to *intuition*. Some even use the word *induction* without any real meaning attached to it, besides some form of reflective intuition. They seemed to confuse Descartes' use of inference in induction, that is, his generalizations from facts; such as he used, for example, in his discovery of the essence of matter, with reflective intuition. As Cushman says: ". . . in the development of his method he (Descartes) found assistance in the traditional scholastic methods. Descartes was original in insisting upon finding the existence of an absolute and undeniable principle before any progress could be made. Such an absolute principle can be obtained only by an *inductive sifting of all ideas*. From this all further truths must be obtained by *deduction*." [12] Fisher, in his discussion of Descartes' method says: "The method of knowledge is, therefore, *synthetic*, since it acquires and forms truths by progressive synthesis. . . . Proof by principle Aristotle called, in a narrower sense, syllogism: in Latin this syllogistic proof is called *deduction;* and with this name Descartes denotes his method, which he distinguished from the deduction of Aristotle. . . . According to Descartes, there is no other criterion of truth than well-understood deduction. . . . *How does deduction begin?* . . . The beginning of deduction is, . . . not an inference, but an immediate certainty, a perception or *intuition*. . . . Intuition is the starting-point of the path of knowledge, and it is made from that point on by means of deduction." [13] Höffding on the contrary is on the right track when he says, "It is evident, from the manner in which deduction is conditioned by the simple empirical intuition, that Descartes is no enemy of the empirical method." [14] It is necessary, however, to study Descartes more intensively in order to see the significance that induction played in his method. That Höffding fails to point

[12] Cushman, *A Beginner's History of Philosophy*, New York, 1919, V. II, pp. 80-81.

[13] Fisher, *Descartes and His School* (tr. by Cordy, ed. by Porter), London, 1887, pp. 317-18; pp. 324-25. See also, Weber, *History of Philosophy* (tr. by Thilly), New York, 1903, pp. 306ff.; Falckenberg, *History of Modern Philosophy*, pp. 86-88; Levy-Bruhl, *History of Modern Philosophy in France*, London, 1889, pp. 10ff.

[14] Höffding, *A History of Modern Philosophy*, V. I, pp. 220. See also, Wildenbaund, *History of Philosophy* (tr. by Tufts), p. 390.

out, especially in its specific application by Descartes, as much as he fails to point out the relation of induction to mathematics.

It is true, as is generally believed, that Descartes was influenced by mathematics, especially in his formulation of scientific method.[15] But, it is not true that the mathematical method is necessarily a deductive one. As a matter of fact, mathematics like any other science, can be inductive, that is, it can proceed from the particular to the general. Especially is that true in the field of mathematical analysis.[16] Descartes, as we know, did his greatest work in mathematics in that field. It is only by mathematical induction that we can ascend; it alone can only teach something new. It is true that mathematical induction differs in certain respects from physical induction, but not in its essence.[17] "It is by this procedure of mathematical induction that the analysts have made science progress, and if we examine the detail itself of their demonstrations, we shall find it there at each instant beside the classic syllogism of Aristotle. We, therefore, see already that the analysts are not simply makers of syllogism after the fashion of scholastics . . ."[18] It was from the true understanding of mathematical method, which implies induction as well as deduction, that Descartes developed his method, which begins with observation of fact. From this in turn spring the general propositions which are clear and distinct, and from these by the aid of deduction a complex body of knowledge, which is the *true* metaphysics. For Descartes no more than for the Greeks of Euclid's time did these so-called axioms spring from anything else than from every-day experience of particular fact. It was the misunderstand-

[15] While studying mathematics it was that Descartes discovered analytical geometry. Descartes wanted to prove first the practicableness of his new method, not in the real of metaphysics, but by its actual application to the problems of physics and mathematics, publishing his *Dioptrics, Meteors, Geometry.*

[16] As early as the time of Euclid, mathematical analysis was distinguished from synthesis. "Analysis is the obtaining of the thing sought by assuming it and so reasoning up to an admitted truth; synthesis is the obtaining of the thing sought by reasoning up to the inference and proof of it." (Euclid, XIII, 5. Probably framed by Eudoxus.) Analysis was used by the Greeks to aid in the discovery of synthetic solutions. The term *induction* in mathematical writings was used as early as 1656 by John Wallis in his *Arithmetica infinitorum.* In 1686 Jacob Bernouilli criticised Wallis for using a method which is not, as he thought, logically binding. From that time on, and especially by de Morgan, who apparently for the first time used the term *mathematical induction* in one of his numerous articles, *"Induction (Mathematics),"* the term *induction* appears sparingly in mathematical writings. In Germany under the name of *vollstandige induktion,* after the appearance of *Dedekind's Was sind und was sollen die Zahlen,* in 1887 it became generally accepted and frequently used.

[17] I have more fully discussed the above in the following two papers: *The Rôle of Mathematics in Physics,* Journal of Philosophy, for July 21, 1921, and *Time and Speculative Philosophy, Monist,* for October, 1919.

ing of the meaning and origin of Euclid's axioms in the seventeenth century, from which Descartes was free,[19] that gave rise to the erroneous ideas about mathematical method from which we were able to free ourselves only two generations ago.

The inductive part of his method, Descartes thinks, should be used not only as the starting point of a systematic philosophy, but also, as often as may be necessary and expedient, to derive some universal principle, from which, by the aid of deduction, new knowledge can be derived.

To exemplify the method employed by Descartes, we shall use two specific instances. Descartes argues that he can doubt the existence of a material world, and even of mathematical truths. But he is certain that there is doubt; he is sure that there is present an act of consciousness when he doubts, wills, desires, etc. He may disbelieve the testimony of his consciousness at a given moment when he doubts, but nevertheless there is still the consciousness of his doubting. Every act of knowledge is a definite act of consciousness. With that act of consciousness Descartes discovers his *cogito ergo sum.* Descartes does not prove or deduce this fundamental truth of the existence of his ego from the momentary act of consciousness; he realizes it as a matter of *immediate reflective induction.* From that single principle of absolute certainty, by the aid of deduction, he gains the "true" knowledge of the objective world.

Descartes uses *induction* again in his discussion of the existence of an objective material world. Descartes proceeds to inquire what it is that we distinctly perceive when we perceive an external object. Consider a piece of wax; if it is fresh, "having been but recently taken from the bee-hive, it has not yet lost the sweetness of honey it contained; but still retains somewhat of the odor of the flowers from which it was gathered; its color, figure, size, and apparent (to the sight); it is hard, cold, easily handled; and sounds when struck upon with the finger. I find, all that contributes to make a body as distinctly known as possible, is found in the one before us. But, while I am speaking, let it be placed near the fire—what remains of the taste exhales, the smell evaporates, the contour changes, its figure is destroyed, its size increases, it becomes liquid, it grows hot, it can hardly be handled, and although struck upon, it emits no sound.

[18] Poincaré, *The Foundation of Science* (tr. by Halsted), New York, 1913, p. 220. See also, pp. 40-41.

[19] See author's paper, *Spinoza's Use of "Euclidean Form" of Exposition, Monist,* for April, 1923.

Does the same wax still remain after the change? It must be admitted that it does remain . . . what then was it I knew with so much distinctness in the piece of wax? Assuredly, it could be nothing of all that I observed by means of senses, since all things that fell under taste, smell, sight, touch, and hearing are changes and yet the same wax remains."[20] But that which constantly remains is that which, whether it is to be large or small, must fill a proportional amount of space. In addition it always has a figure, whether round, square, or triangular; and, by virtue of being extended, it can be moved. From these observations of facts, Descartes by his *inductive method* infers that these three qualities are the only qualities which are the essence and self-identity of the piece of wax, while the other sensible qualities are only known obscurely and confusedly. This true knowledge of the mode of the material world constitutes for Descartes a principle of absolute certainty from which by deduction he derives other knowledge, e. g., that there is only one kind of matter, that there is no empty space, that matter must be continuous like space, etc., etc.

Descartes' methodical contribution to philosophy had fruitful results in the field of systematic philosophy, but in the field of methodology it soon became misunderstood. Descartes believed in mathematics as the universal science. Being a mathematician of the first rank, he must have understood some of the fundamental principles of it, but not so with his followers. Mathematics was not yet in a position in which she could understand herself, much less be understood by others. The deductive part of his method taken at its face value, being easy to grasp, was seized by his rationalistic disciples, who neglected to look deeper into the method of their master. Favored by the monastic tendency of the Cartesian methodology, i. e., the fact that it set up the highest universal truth from which all other certainty should follow, the traditional *more geometrico* procedure was adopted by the Port Royal Logic. The ideal of philosophy at the time, became to develop from a body of universal principles all its knowledge into a system which was rigid, logical, and coherent. It was natural, therefore, for the age to consider Euclid's elements as the ideal of methods. The age, therefore, attempted to arrange all propositions so as to form a chain of geometrical reasoning, beginning from simple, clear ideas regarded as truism and proceeding by small steps to results of considerable complexity.

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[20] *Medid.* 11 (tr. by Veitch), pp. 110-111.

NUPTIALS IN HIGH LIFE

THE story goes that on a certain occasion, when many were thanking the Philosopher of Concord at the close of an eloquent address, a highly-cultured lady exclaimed: "Oh, Mr. Emerson! You make such beautiful use of the word 'unique'!" Instantly the sage drew forth his notebook and inscribed: "Never use the word 'unique'." However, even he might have felt sorely tempted, had he lived to review the *Mathematical Philosophy* of Professor C. J. Keyser—in fact, the clear and calm thinking Dr. G. A. Miller does use it twice in his notice of the work, in *Science*, 25th August, 1921, page 229! For where shall we find its likeness in the library of today? A course of twenty-one lectures (462 pages) discussing such themes as "Postulates," "Basic Concepts," "Transformation," "Invariance," "The Group Concept," "Infinity," "Hyperspaces," "Non-Euclidean Geometries," "The Mathematics of Psychology," with others of their kith and kin. Throwing open the book entirely at random, we behold pages 92 and 93 shining with twelve equations in x and y, and s and λ, and others, along with definitions of "dyads" and "segments"; there are not a few other such pages, some of them given to geometric figures, as of "pathopencils," but the great majority are in ordinary print, though sprinkled with symbols, generally capitals, as the sky at night is sprinkled with stars.

However, it is by no means night that reigns over this expanse; on the contrary, it is broadest daylight poured out from a wonderfully clear and sunlike intelligence. True, the discussion cannot be fully comprehended without some effort; now, no less than in Hesiod's day, the gods have placed labor before all excellence; the victorious spear of Atrides was one that "tempests had toughened." We are told, indeed, that the day of the textbook is fading to its fall; that the "movie" must take its place; that the child will have little need to study or think, it will be enough for him, like the Apocalyptist, to "Come and See"—the film with all its picture-tales

of wonder. As the educational vision glides by, he may lie back leisurely and chew his gum or crack his peanuts. What better way to understand a complicated machine than to watch it work. If it works, must it not be "true"? Civilization, even History itself, is little more (they say) than elaborate conjugation, in both voices, of the verb "to eat." Why not master the Greek language and at the same time learn the prevailing economics by watching a "movie" unroll in all its countless inflections and contortions that typical favorite of grammarians, *typto,* "I strike"?

But Prof. Keyser has not gone quite so far along the primrose paths of progress. He still calls on the reader, in every paragraph, to think. For such as find joy in thinking it will be keen and pure delight to share with him his feast of reason. Nor will the flow of soul be anyway lacking. The table sparkles as well as groans. Prof. Keyser's style is notably brilliant; his pen flashes with imagery often highly poetic; exactness and clearness of thought are matched by precision and elegance of phrase. His vocabulary is rich and ready; the most fitting word stands waiting to be bidden; enlightening antitheses and just discriminations enkindle the reader's interest and spread the glow of understanding about him. In discussing the Group Concept, who else might not have been content to cite the rotations of a wheel and the displacements or translations represented by vectors; but Keyser calls on us to imagine a squirrel turning its cylinder in a cage, and a host of angels flying in mid heaven. Often we are reminded of Homer, who brings forth from the treasury of his similes both the simplest and the sublimest, and with equal artistic effect. Homeric, too, the author's honesty and unqualified candor, as in the frank and repeated admission, "I do not know," when curiosity and alertness have raised a question they cannot lay. His enthusiasms abound; yet, while overflowing with admiration for the great thinkers of all ages and countries, he worships none of them blindly, but with eyes wide open to their limitations, dealing out judgments with the right hand, but also with the left. Astonishing in what a goodly company of the elect of all times he roams through the fields of Reason. Look at the index of proper names, over two hundred in number; observe how they range from Aristotle to Wellington Koo, from the Hindue Kanadi to the Fundamentalist Bryan, from Plato to Rückert, from Henri Poincaré to Lenine, from Thales to John Henry Newman, from the cheerful Socrates to the melancholy Inge. Consider the references, nearly 450 in tale; many,

of course, are merely mentions of a name, but hundreds cite either words or ideas. Observe also the favorites in this bright assemblage, as Aristotle, Cantor, Clifford, Descartes, Euclid, Fechner, Hilbert, Wm. James, Kant, Korzybski, Lucretius, Plato, Henri, Poincaré, Russell, Whitehead and others! Certainly a generous heart and a catholic taste as well as a discerning spirit—no sessile narrow-sighted specialist but a wide-ranging intelligence—that has gathered this congregation and compacted this volume,

> A honey-bee that wanders all day long
> The hill, the valley, and the woodland o'er.

More, however, than the breadth and variety of intellectual interests, than the far and frequent excursions of thought, more even than the depth of musings on dark and hidden mysteries, is the altitude of flight, the strong upward urge of the author's spirit into clear cold regions of the purest Logic. He might exclaim with Nietzsche:

> I've sought the peaks where blows the keenest air,
> And few there be find breathing easy there.

It is indeed to mountain-climbing that the reader is invited. The guide strides along, on the tall and slender but steady and infrangible stilts of mathematical conception, from summit to summit, and draws the traveler with him, pausing at every new point of view to indicate the beauty and sublimity and wonder of the vision disclosed, always broad and bright, though sometimes chill and bare.

Most of all, however, it is the fine humanity of the work, that touches the heart and awakens the sympathy of the reader. It is not Logic merely as Logic, nor Mathematics as Mathematics, nor even Philosophy as Philosophy, that is the most immediate and pressing interest of this volume; its most intimate concern is with Man as Man, with human life, with the human soul, with the "Emancipation" (as the Professor loves to call it) of the Human Spirit. These long-continued and penetrating studies have been inspired by the Love of Man and have aimed at his salvation through the Truth. Freedom[1] has been their guiding star, and "The Truth shall make you free." It is Democracy that Keyser wants made safe in the world; not a mere political or economic, a capitalistic or socialistic organization, but a spiritual Democracy, a Republic of minds, of

[1] In this time and clime, it is hard to use this word without a pang.

emancipated souls. The goal seems indeed far off, but the author's foresight is clear and steady, his Will is set and unwavering. It is warm enswathing human interest that distinguishes the Columbian from such illustrious English masters as Whitehead and Russell. Not that these noblemen of nature are indifferent to things human, but the glow of feeling for one's fellows, the Terentian "Naught that's human is foreign to me," is felt still more distinctly in the American's writings. It is highly significant and appropriate that these discussions have taken the form of lectures to students, or rather of the most familiar talks, in which the author figures almost as an elder brother.

II

And this brings up directly a question that has doubtless been waiting for recognition, impatiently, in the reader's mind: For whom are these Lectures intended? Unto whom were they first addressed? The lecturer has taken just pains to tell us who, in his opinion, might profit from perusal. The preface presents us the outcome of more than forty years' "meditation upon the nature of Mathematics, upon its significance in Thought, and upon its bearings on human Life"—a very clear and satisfying statement. The "course of lectures" is intended "to present in the language current among educated men and women, some of the maturer fruits of that study" —but many such readers may suspect he has over-assessed their education; though "designed primarily for students whose major interest is Philosophy," "the lectures may not be ungrateful to a much wider circle," which includes seven sub-circles of certain (not all) "professional mathematicians," "teachers of mathematics," "natural-science students," "literary critics," "psychologists"—with mathematical interests, "sociologists"—who would "conceive the nature of our human kind justly," "engineers"—who would "conceive engineering worthily," that is, for the welfare of all, present and future; but these seven inner circles cannot include all the area of the one large circle, and so we have an eighth sub-class of "all readers who desire to acquire a fair understanding of such genuinely great mathematical ideas as are accessible to all educated laymen, and to come thus into touch with the universal spirit of the science

which Plato called divine"—as we take it, by far the most important group of the author's readers. Whoever is one of these could hardly employ a week more profitably, with richer result in expansion, uplift, illumination, than in careful and repeated study of the work in question. As conclusive proof of this statement one might quote the avowal of the distinguished reviewer already cited, a master of Group Theory: "In fact, the present writer found the lecture devoted to the group concept worthy of a second reading although he had given much thought to this particular concept before reading this lecture"—a more significant tribute than another might pay in many pages.

So much, however, is not enough. The prospective reader will still want to know more definitely what he may hope to find in this volume, what menu of thought will be laid before him—must he take each entry as it comes, or make his own selection? The answer to the latter query is that it would generally be best to take the whole course (at least, on first reading) just as it stands, but it is not necessary: the lectures are each in a measure self-contained; there is some interdependence, and the later hark back from time to time to the earlier; nevertheless, the presentation is so self-luminous that the reader may "cut" a lecture now and then, like a typical "student," and still follow the next without wearisome effort. But a satisfactory answer to the first question is not so easy. The Table of Contents denominates in six pages the matters treated, but any such enumeration, consisting almost wholly of substantives or substantive phrases, would be meaningless in a review. The lecturer makes pass before us a splendid array of ideas, of concepts; he points out the definitive features of each, he shows vividly their beauty and significance and the marvels of their interrelations; but he is not engaged formally in controversy (only incidentally, now and then), he is not weaving a web of argument, not forging a chain of syllogisms. His task is analytic and conceptual rather than synthetic or demonstrative. "Broad outpours the speech of reason," but not in torrents of disputation, rather as a gentle "mist" of exposition, watering "the whole of the earth." For this reason the book lends itself unwillingly to summary.

Yet we may say that the first Lecture, the "Introduction," defines the author's general attitude both as to Philosophy (Ontology) and more especially as to Mathematics as an element of liberal culture. In regard to the former his position seems to be extremely interest-

ing and to call for special treatment later; in regard to the latter, it is notably sane and moderate, one might almost say over-moderate. He would call for no more Mathematics in the general curriculum (if so we may understand the words, "amount of mathematical training essential to the appropriate education of men and women as human beings") than "is the amount necessary to give them a fair understanding of Rigor as the standard (the "Muse") of logical rectitude," and for "pupils of fair mathematical endowment, a collegiate freshman year or even a high school senior year of geometry and algebra" ought to be "sufficient." Certainly little enough to satisfy all but the thorough-goers, who put the study of Algebra and Geometry quite on a par with boiling beans and peeling potatoes.

Keyser seems right in thinking a year of the two subjects, taught in the proper spirit, might appease the Muse of logical Rigor, might sufficiently stimulate the germ of thought—necessity in the average mind; but such a minimum of actual available knowledge, of concept-formation, seems too small for a liberally cultured soul. To me, at least, the marriage of the two disciplines, as celebrated in Analytic Geometry, seems essential and necessary, if the two are to be properly fruitful. The notion of one-to-one correspondence (as of a point in a plane to a number-pair) or of a point in three-fold space to a number-triplet) seems so fundamental and vital that a cultured intelligence appears lame without it. Hardly so indispensible, yet of surpassing importance, is the notion of Limit, not necessarily in the refinement of the Professor's analysis, but even "in the rough," as for centuries it served the purpose of Euler, Lagrange, and Hamilton. If to these were added the concepts of Function, Invariant, and Infinity, the graduate might go forth not only cultured but also equipped.

But would it not require a great expenditure of time and energy to be diverted from the Social Column of *College Chat?* By no means! A summer course might well suffice, if given with intelligence and spirit, and taken with diligence and will to know. Even the Cross-Ratio, that wonderful Invariant, might be made familiar, if not reduced to ready obedience. For general purposes educational and intellectual—one may still be allowed to employ this latter adjective, though it is fast becoming a term of suspicion and contempt—such a course, entirely in the spirit of this volume but far less ambitious and rigorous, need not yield in value to any now offered in the University world of America. What then might be said of

the Keyser course as actually given at Columbia? The misgiving is abroad that the average of earnestness in the collegiate masses has fallen notably in recent years. Such an apprehension is not easy to confirm but still less easy to allay. But in any case the book in hand proves clearly that there are earnest and capable students of philosophy on Morningside Heights. No others would have elected and attended such a course of lectures. Even more conclusive is the implied testimony to the skill and eloquence of the lecturer, above all, to arousing, illumining and vivifying qualities in his exposition.

It is not practicable, though it might be profitable, to follow the author through this banquet of Logic, to observe how deftly he distributes the nectar of his doctrine—immortal draughts not in golden goblets but in cut-glass beakers that flash like diamonds. How delicate they appear! What more than acrobatic dexterity seems needed in the handling! We must hasten on but not turn away without a few further general observations. And first, as to the title, "Mathematical Philosophy." It is well-known that philosophy has faced both ways, now this now that, in the course of history—in the earliest days, directly toward mathematics:[2] Thales, who heads the Greek list, was geometer and astronomer; Pythagoras was interested, most of all things, in Numbers; Plato "required" geometry as condition of admittance to his Academy; but with Aristotle her face was turned toward Biology and Nature-Lore. In the new birth of Philosophy under Descartes and his successors, the pendulum swung far toward Mathematics again; but with Hegel, Schelling, Schopenhauer and the nineteenth century, the swing was once more to Biology and Natural Science. With the rise of Logistic, Twentieth Century Philosophy turns again to the elder love, to Mathematics.

III

It is not strange, then, the title of the work, nor that the author marches boldly, even proudly, under the banner of Plato and the Doctrine of Ideas. This allegiance is disclosed in every lecture but most distinctly avowed in the first, the Introduction, where it is

[2] If we leave out of account the "latent philosophy" recognized by Thalisso von Scheffer in the Homeric poems.

declared at the outset (p. 2ff): "We are going to deal with ideas—with their characters, with their meanings, with their relations. Now, an idea is in itself an eternal thing and the relations of an idea with other ideas are eternal. An idea is just what it is and it is unalterable; a relation among ideas is just what it is and it is unalterable." An admirably candid and unequivocal statement. Though we may speak of "ideas and their relations" as "temporal affairs" subject to "change," "capable of growth, of modification, of decay, of destruction," yet it is not really so, all such speech is only figurative; though we may abandon one idea and adopt another, yet "neither has been transmuted into the other; each of them remains and will remain just what it was." These eternals are represented by man-made symbols, as "2, 7, 9, + and =," "but the things they stand for, though they were discovered by man, are not man-made; they are increate . . . and indestructible, and the like is true of their relations"; "the statement expressing the relation (2+7=9) is a creature of man, but the relation itself is not—man discovered it, but he did not make it—it is a thing increate and indestructible, the same yesterday, today and forever." This eternality may not be "equally evident" in all other cases of "ideas and their relations," "but it is none the less true." These constitute "a world—the world of ideas"; from dealing with it "there is no escape" for human beings; "these and only these" "foundations are found"—for science, philosophy, art, religion, ethics, government, education—for human life in all its phases; there only man may find "principles or basis for rational theories" and practice; he may choose, but some choice is necessary—since "to be really human" is "to be rational," and the choice once made the "destiny of consequences" begins to spin "beyond the power of passion or will'; "another choice of principles is but the election of another destiny. The world of ideas, you see, is the empire of Fate."

"Is the human Intellect, then, a slave? No: it is free" (free, it would seem to "choose" its own master); "but its freedom[3] is not absolute; it is limited by fact and by law—by the laws of thought, by the immutable character of ideas and by their unchanging eternal relationships. Intellectual freedom is freedom to think in accord with the laws of thought[3] in accord with the nature of ideas, in accord with their interrelations, which are unalterable. And no variety of human freedom—no institution erected in its sacred name

[3] Would it be easy to *think* otherwise?

—if it does not conform to the eternal conditions of intellectual freedom—can stand." Hence, the "work in these lectures is to be fundamentally a study of Freedom and Fate."

The reader will not ask any apology for these long citations, for in such Prof. Keyser has laid open his heart with "intriguing" sincerity and clarity; as Homer or Vergil proclaims the whole burden of his song in the first hexameter, so too our author in the first five pages. The refrain is heard again and again, but it would be hard to improve on this bold initial statement, bare and clean-cut as the mountain against the sky. Such, then, is the Philosophy of this mathematician,—undoubtedly a sublime and imposing system. Its general appearance recalls the groves of Academe, and Plato is in fact very frequently cited; however, the Keyser-temple is not built after the ancient model, but in the most modern fashion imaginable; it is steel-framed, concrete-based, many-chambered, and scrapes the sky. The builder has chosen his own "principles" "for rational theories," and they are the "Principles of Mathematics," especially of Logistic, the "Principia Mathematica" of Whitehead and Russell, of Frege and Couturat and Peano. Any criticism of these solid-seeming principles—in this review—is of course entirely out of the question, but it may not be out of place to make some general observations and propound some near-lying questions and hesitations—not indeed so much on the work in hand as on the majestic system of Ontology that it adumbrates and implies.

IV

The World of Ideas! A sublime conception—but what are its contents? Numbers, such as *2*, *7*, *9*, relations between them, as addition (+) and equality (=). Excellent examples, but they do not satisfy. Doubtless, also, points and lines and planes and spaces, dyads, triads, manifolds and the like, the empty forms of propositions and of doctrines (connectivities of propositions), beautifully named Propositional and Doctrinal Functions; but even this endless array is not all; there are countless others; we speak of the idea of man, of beast, of tree, of good and true, of any and everything that we can talk or think about. Of all these we learn only that they are eternal and immutable—which may be much, but can hardly be all.

Still more, however, we must ask how these Ideas are related to man, to the human spirit? The only answer given is that he "discovers" them. This then seems to be the situation: The Ideas are a World in and of themselves, a shining firmament spread above our sky, a wholly *static* Universe, unchangeable in themselves and their interrelations, with no beginning, no growth, no end—entirely timeless; not merely a perpetuity, but an eternity; not like an infinite straight line, but rather like a circle, where each point A is both before and behind every other B and between every couple BC. Assuredly, a stupendous imagination, an awesome vision, like the four-dimensioned absolutely stationary Time—Space or Event-World or History-Universe of Minkowski, Einstein, and Whitehead (however different in content).

But we must ask again, What has this Static Idea-World to do with the world of man? Prof. Keyser has some remarkable pages (22ff) on "Idealization" and the "Platonic Absolutes" as "radiant *ideals* of concepts, shining from above them like downward-looking aspects of an over-world"—"beyond" the intellectual world (of ideas?); but all this, though inspiring, does not relieve the difficulties concerning the world of Ideas. It is not enough to say that man "discovers" it (whatever that may mean), and regulates his temporalities by its eternities. These may be and are in fact impressive words, but what do they mean? Whitehead and Russell and Keyser, a brave trio, do not answer. The second, indeed, more militant than his peers, seems to hold the man-world in utter contempt. In a passage quoted with apparent approval he says: "Pure logic, and pure mathematics (which is the same thing), aims at being true, in Leibnitzian phraseology, in all possible worlds and not merely in this higgledy-piggledy job-lot of a world in which chance has imprisoned us." This "striking utterance" may be "poignant" enough, but it seems to be quite unwarranted and unworthy.[4] Far preferable the parallel pronouncement of Keyser himself, that the aim of Mathematics "is to think rigorously whatever is rigorously thinkable or whatever may become rigorously thinkable in the course of the upward striving and refining evolution of ideas." This seems to be far nearer "true" than the acrid denouncement of Russell. Only alas! it speaks of "becoming" and of an "evolution of ideas." But how can these things be, if ideas and their relations are all

[4] Though there was much to provoke it, when it was first written, and little, if any, less now.

unchangeable eternalities? In a timeless static world of ideas there can be no "upward striving and refining evolution." Perhaps it will be said that the expression was merely elliptic, that the meaning is that the human "discovery"-process was such an "upward striving and refining evolution of ideas"; that it is man himself that strives upward and refines his own discoveries of ideas—which seems much nearer to the facts in the case, though still unsatisfying. It is not easy to see that one Idea in such a throng of eternals would not be just as good as any other (like the points A, B, C, of a circle); any hierarchy, any upper or lower world seems to exist not at all in the Idea world itself, but only in man's method of approach, in his way of regarding it; the grading would appear to be unjustly degrading and entirely man-made.

So it seems that Man, the human spirit, has something after all to do with the world of ideas; and now to hasten on, we must ask boldly: What right has Keyser or his school to affirm that Man, the human spirit, is merely a "discoverer" of Ideas, or of anything else, entirely extra-human, independent of the discoverer, already there before him, and still there after him the same yesterday, today and forever? How do we know that these ideas (whatever they be) and their relations are "increate and indestructible," that they are in no sense, in no measure, in no manner the products, the outputs of the human Spirit in the endless historic and prehistoric process of the "upward striving and refining evolution of ideas"? Let the issue be joined sharply and at once: We do not know it at all. No sufficient reason has yet been assigned, and none seems even assignable, for denying creative activity to Spirit, to the Individual Spirit, still less to the Spirit Universal—a distinction that need not now be elaborated.

V

In fact, what do we know of Spirit of mind at all, *except as such creative activity?* So at least it has long seemed to me ever more and more clearly. The lowest form of such *conscious* activity is known in sensation, but this *tends* to body itself forth in its (alleged) cause, ever more and more distinctly. We do not merely feel, we feel *something.* Hence, Sensation passes over "refined" into Perception, which takes its highest objective form in Sight. We do

not merely see, we see *something,* an object. What is it? Look with both eyes straight at the moon, holding a pencil directly in front of your eyes. You see two pencils. Look at the pencil. You see two moons. The double moon (or pencil) is manifestly an ***external construct created*** by the percipient subject, You. So then is the single moon (or pencil), which is only the two fallen together. The sight-world is thus *continually* built up double; in the horopter (line or surface) the two corresponding constructs fall into one. Similarly, the reflected world behind the mirror; similarly the whole world of dreams and visions—the raw material of reality. In case of the other senses the objective creation is of far lower order but of the same general nature. Outward objects are always constructs, "complexes of projected sensory responses" (Head, *Sensation and the Cerebral Cortex*), creations of the experiencing subject; their *esse* is not *percipi* but *præponi.* (Some may ask, "Responses" to what? Answer: To the whole extra-conscious-Individual determination or status—constantly fluctuating—of the one Universal Spirit —Activity.)

In the still higher form of Conceptualization, the creative activity of mind is if possible still more apparent. In such as the great trio, Whitehead-Russell-Keyser, it is carried almost to dizzying heights; the concepts are created and objectified, like vivid percepts, and denominated Eternals increate. But just as each one (so Russell now seems to recognize, see his review in *Mind* of Broad's *Perception, Physics and Reality*) creates continually his own world of percepts, spinning it *out* from the depths of his being (unconscious, universal) as the silkworm spins its cocoon, so each one makes his own system of concepts, of "eternal" ideas. And there are countless grades in this process also, the germs of number-sense reach low down the scale,—even a crow may count three. A long way thence to the concepts of a Keyser! But the ladder reaches both ways far beyond, without end. Each Individual, that is, each phase of the one Universal Spirit, spins constantly its own objective world about it (reminding us of Aristotle's dictum, that Mind is all in the whole and all in every part) and these worlds differ endlessly in order and degree; even among Individuals so nearly alike as the class of men the variations are limitless, but the permanent agreements are incomparably more and greater, so that A and B may speak and act *as if* their own different moons were the same, and independent of each, and out there somewhere, a something to be

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"discovered," indifferent to any and all percipients of whatever order or degree. *There is no such moon.*

Similarly, the Anglo-American school proclaims a world of Ideas and their relations, a conceptual world increate and imperible and wholly independent of the conceiving ideating Mind. In the reviewer's judgment, there are no such ideas, there is no such world. The observer imagines he *discovers* the moon or the microbe when he sees it with natural eye or with artificial 'scope (as Columbus imagined he discovered the Indians in America. This striking illustration is elsewhere used by Keyser in a notable passage, that has received the high and just honor of citation by Ernst Cassirer). But what is the fact? When he sees the moon he is *not* discovering something already there, however plausible the phrase may sound; his moon is his own instantaneous creation; the whole material—spatial relation of perceiving organism and perceived moon is a *Symbolism*, a *Construct*, which the observer-mind makes, creates, projects, instantaneously when experiencing the specific activity which *in its objectified form* is named seeing-the-moon. What that activity was or is *apart* from this symbolism we do not know, perhaps we shall never know, it may be unknowable; symbolism in some form may inhere essentially in the conscious mind-process itself. Says Goethe: "The deepest can be said in symbols only," and perhaps the shallowest, also. Certain it is that the Symbol reigns in all our cognizable activities. "Qu' est-ce qu'un mot?" asks the Frenchman. The stenographer makes a mark, an abbreviation or arbitrary symbol of a written word; which is itself the symbol of a word spoken; which is the symbol of certain aerial-aural agitations (on the one side) and of certain muscular throat-tongue-lip determinations (on the other); and these symbolize certain neural-cerebral determinations; and these symbolize certain psychic activities. The path is another and dimmer with the symbols in Ideation and Conception, but it is there.

The cold and clear-thinking Western mind is strongly disposed to freeze its own creations—its own liquid symbols of its own fathomless processes—into shining crystals, which it then regards as independent objective facts, whether of Science or Nature or History, forgetting and disowning its own children, like animals and plants of the field. In this way not only Philosophy but also Religion suffers perversion and becomes unintelligible. The most splendid example of all time lies all around us and is only now

beginning to be realized and understood. The grandest of all historical movements (the Protochristian, from B. C. to A. D. 150) was born and spread all round the Mediterranean in a glorious cloud of highly poetic symbols that still shine in the Gospels—wholly misunderstood and misinterpreted, reminding us sadly of the "works" about which Goethe sings:

> The lofty works, uncomprehended,
> Are bright as on Creation's day.

The Orient is far more tender to such creations of its soul than the West, and for a while it recognized its own symbolism, even as late as Origen; but the prosaic Latin Soul, like the face of Medusa, speedily turned the whole structure into stone, the senseless stones of History and Biography, and threw the whole crushing burden on the mind of the West, under which for eighteen centuries it has groaned—and in the ignorant wrangling of Fundamentalist and Modernist it groans still, louder than ever. Only within the last few months has the chief West-European Biblicist, Alfred Loisy, in his epoch-marking book *Les Livres du Nouveau Testament* (following boldly the lines already laid down distinctly twelve years ago in *Ecce Deus*) lifted the veil so long lying on the fact of Scripture and published to all men the wholly *symbolic* sense of the Gospel story.

VI

But Russell and the rest are ready to exclaim "Nonsense! The Idea must be *not* individual but Universal, for it holds for all men, for all mind, in all possible worlds, the same yesterday, today and forever. The equation 2+7=9 is just as valid on Mars or Arcturus as here in England or America." And who will deny? The validity does indeed seem to be universal, the same for Briton and for Hottentot, and *suggests complete independence of the Individual.* But does it *prove* such independence? By no means! One would like to see the syllogism. Apparently the same moon is beheld by us all, the same stars and planets. Yet it is certain that each beholder constructs, creates, his own moon (generally double) in the act of vision. But why are the moons all alike? The answer is easy: they are all symbols of psychic activities in Individuals (phases of the

One Spirit), and these are all profoundly and minutely but not absolutely alike—as neither are the moons. In poetic-artistic contemplation the activities may vary appreciably, and the moon-symbols likewise; in scientific observation they are much nearer identical, and the moon-symbols also. Science deals with constants, with that about which we may all very nearly, indefinitely nearly, agree; that is, scientific activities are from Individual to Individual sensibly the same. Science is a study of the Unity of Nature, of unvaried orders called Laws. On the surface of things this Oneness, this Invariance, is shivered into endless Individuality, diversity and even opposition; Science must drop the plummet further and further down to "discover" the Unity hid below. The discovery is, of course, in the realm of symbols, there is no otherwhere to hunt. But these symbols are all the products of Mind—we know of no others—and any permanence found among them is only the shadow or reflection, the *Abbild,* of a permanence amid the psychic activities they symbolize.

These sketchy remarks apply to concepts with no less or even greater force than to percepts. The rigidity of a Fermatian equation is not harder to understand than the rigidity of the ether or the steady twinkle of a star. Each is only an image of a corresponding steadiness in the psychic activities of the whole sphere (surface) of spiritual Being,—for we may liken such Being to such a surface, wrinkled crinkled sprinkled dappled with countless Individualities of every order and degree—each wavelet gleaming and pulsing in Consciousness and yet spreading its unconscious continuation throughout the Whole. The facts and the laws of Nature are types of the modes and norms of this cosmic activity, of the pivots and axes of Universal Experience, they are "the rhymes of the Universe." Such a symbolistic doctrine should present difficulty least of all to a mathematician, who may well think of the Spirit-Universe as a vast equation U=O, where U contains numberless psychic activities in ultra-complicated relations. How would he study such an Equation? One way would be to depict it in a Space, in a vision of a World. If Time be one of the dimensions he would thus secure a picture of History, to contemplate at leisure and at will. He would not be surprised to find all sorts of Laws and rigid relations in this gigantic Time-Space symbol, and he would refer them all without a moment's hesitation to corresponding timeless, spaceless changeless relations in the original Universe U. Something of

this kind seems actually to have been done, for symbolization in some form seems native and vital to psychic Activity.

Space fails for further discussion, but it must not be inferred that the opposition of views here developed and exposed is necessarily fundamental and irreconcilable. In my judgment the logistic or mathematical swing of the pendulum of philosophy was needed and essential and in the highest degree significant and important, and America should be proud to have contributed side by side with Italy, Germany, England, France to such a splendid development of thought. But the development has not been quite symmetric, the biologic element has not quite come to its own. Another accent is now needed, an accent on Spirit and Growth. The later works of Whitehead and Russell seem to show the twain awake to the true condition and ready with remarkable magnanimity and open-mindedness for any required sea-change of doctrine, for which, indeed, Professor Keyser, with his noble and beautiful Humanism, could not be less prepared. In fact, we find a passage (p. 148) that seems to indicate unmistakably that he has a very definite premonition of a transfer of the sublime Invariance, supposed to clothe the increate eternal extra-human and even extra-mental Ideas, to the Mind itself: "You will find that within the doctrine, however formless, however ill ordered its parts, however loosely knit its texture, there is shadowed forth more or less clearly, very dimly it may be, something of the figure and frame of the logical prototype called doctrinal function, as if this thing were so built into the very constitution of intellect as in some measure to guide and shape its activity whither we will or no." A most important deliverance. There is no quarrel about words. Of course, the reviewer would not say "built into" but rather "born with," congenital co-eternal. We talk of implanting ideas, but we do nothing of the kind, we merely stimulate into active life. Unless the germ of the oak is there, the tree will never spring forth, water and fertilize the soil as you will. Neither have we any stock of germ-ideas to plant. Like all tendencies to variation, mutation, development, these are there already, though outward impact may start or sustain their growth.

There are multitudes of other things in this volume that might provoke discussion, though rarely contradiction. On second reading the reviewer jotted down six large pages of close-compacted notes and observations—none of which have been consulted in writing this review! In particular, a word might appear due to the pos-

sibly over-worked definition of abstractions by means of the notion of class; also the distinction between "important" and "indispensable" (p. 330) must give us serious pause; but socio-economics is tabu in this review, which is much too long already. Enough, that *Mathematical Philosophy* is in every way a noble and brilliant work, informed by the largest exact knowledge, shared by the keenest acumen, dictated by poetic feeling and literary taste, inspired by a generous and humanistic spirit. The book will be a boon to its readers, even such as may read it only in part; it honors the University of its birth—and no less the publisher, who seems to be sharply distinguished from a competitor who recently declared himself quite indifferent to "literary quality" and concerned only for the "popular appeal."

WILLIAM BENJAMIN SMITH.

THE SIGNIFICANCE OF THE SPACE-TIME CONTINUUM

THE abundance of expert literature on the Theory of Relativity has much contributed to clear the fog away from most of the fundamental principles of the theory. But while mathematicians and physicists tend more and more towards a general accord concerning Relativity, philosophers widely diverge in their interpretations of the metaphysical aspect of the new physics. A very strong position seems to have been secured by idealism through the remarkable essays of Prof. Wildow Carr.[1] But if the rational synthesis he has prescribed appeals to imagination and is philosophically possible, the mathematics of Relativity seems to offer little ground for such an interpretation. The Principle of Relativity is not a unique crucial fact to decide between idealism and realism, and in no respect whatever is it idealistic or realistic in any sense in which any other physical principle is not. But a close examination of Einstein's theory will rather show that idealism can only give a particular meaning to the Principle of Relativity, or try to determine the epistemological implications of it, without attempting an adequate discusson of the significance of the mathematical counterpart on which Einstein bases his comments and verbal enunciations. Consequently, the period of philosophical misinterpretation of the Principle of Relativity, as stated in pure science, will continue as long as philosophers refuse to consider a few simple mathematical expressions whose quantitative invariance is all-important in the problems at issue.

In the first place, the meaning of a four-dimensional continuum and of the distance-interval between two points, must thoroughly be grasped, for otherwise, the statement of the theory to the philosopher would resolve itself into a disquieting account of changes, according to position and motions, of things which are usually regarded as invariant, such as the length of the standard metre rod

[1] Cf. *The Principle of Relativity—A Theory of Monads*, and various essays in the *Proceedings of the Aristotelian Society, Nature and Mind.*

or the time recorded by the most accurate clock. There is nothing occult about the four-dimensional continuum. When we consider the universe of events that happen to particles of matter, these events form a continuum in both space and time, and everyone of them has to be characterized by four numbers, three of which give its position in space, while the remaining one denotes the time of the event. But the distance-intervals of the space continuum and the instant-intervals of the time continuum are not absolute in themselves and independent of one another, as it was universally assumed before the advent of Einstein's theory. Space and time are relative to each other, and only when their elements are so combined as to form invariants, their amalgamation constitutes a unique and necessary world, a universe more absolute than that of the classical physics, because of the essential duality of the latter. The space that we see then, is only a three-dimensional facet of this four-dimensional universe; we see different facets as we change our motion, and the mathematical theory of Relativity shows us how to join them together in the four-dimensional whole, just as we join mentally in a three-dimensional picture the various two-dimensional aspects of the same mountains seen on the horizon from different parts of a country. There is, of course, the important distinction that the four-dimensional universe as apprehended by us, is an intellectual synthesis with no imaginary counterpart.

The absoluteness of the four-dimensional continuum is emphasized by the uniqueness of the distance-interval between two events. To make this idea clear, let us consider first a euclidean three-dimensional continuum: between any two points in space there lies a necessary and unique path, the distance-interval, expressed by three coördinates independent of time. The absoluteness of that unique path is claimed only when the three coördinates, or their equivalent, are taken together. The possible variation of each of the coördinates taken separately, necessarily changes the value of the distance-element; so that the coördinates are not absolute in themselves, but relative to one another. It is their combination which is absolute, and whatever be the variation of the one or the other, it is always possible to compensate these variations betwen themselves, so as to leave invariant the value of the group of coördinates taken as one whole. Then we may change the three coördinates of a distance-interval by changing the orientation or the position of the axes of

reference, but the distance-interval remains unchangeable and constant.

The same thing happens in a four-dimensional space-time continuum, be it euclidean as Minkowski's universe, which is nothing but rays of light and small elastic bodies, moving freely or colliding, but without gravitational force, or non-euclidean like Einstein's Riemannian Universe where gravitation is accounted for. In such a space-time world of events, the free tracks of material particles are again necessary and unique tracks; and this is symbolized by their mathematical counterpart, where the distance-intervals joining any two events are invariant in each case. Such a distance-interval is therefore the absolute standard-measure taken by all observers, whatever be the motion of their particular frame of reference. What differs in the methods of measuring time and space for two or more observers moving relatively to one another, is their particular length-unit and their particular time-unit, because there is no such a thing as an absolute space and an absolute time. But when we are discussing space and time with regard to the theory of Relativity, we are not allowed to consider them separately, but take them as a universal and absolute whole. As in the case of the euclidean three-dimensional continuum, the variations in the particular space-coördinates and time-coördinates of different observers moving relatively to one another, compensate in such a way as to make possible the expression of the distance-interval between two events, in terms of a unique space-time continuum and by means of a unique world-line represented mathematically by a unique formula, then, whatever be the degree of dimensionality of the continuum to which the distance between two events is referred, no amount of reasoning will get us away from having to postulate the absoluteness of the interval between those two events.

On the basis of the interpretations of the mathematical expression of the space-time continuum and the distance element, one fails to see on what grounds it can behold that there is no absolute space-time system, and that every space-time system is absolute for those attached to it. Indeed, every spatial system is relative to a degree of freedom indeterminable from within, whence the absoluteness of that system from the standpoint of those attached to it; but, there is no meaning at all in the statement that every space-time system is absolute for those attached to it. What is absolute for all the observers belonging to the same system is their particular space and their

particular time: a detached space-time continuum is meaningless for them. Thus, we must imagine each star carrying its own appropriate space and time according to its motion through the ether. The space and time of one star will not fit the experience of individuals on another star. But, as Professor Eddington says, space-time is the same universally, it is only the orientation, i. e., the resolution into space and time separately, which depends on the motions of the individual, experiencing it, just as the resolution of space into horizontal and vertical depends on his situation.

But all this comes to the affirmation of an existence independent of sense experience, to which the subject of experience refers his sensations. There is little ground then in saying that the Principle of Relativity accepts sensations and perceptions as themselves the Reality, and as the only Reality with which science is concerned. What Einstein set himself to discover by mathematical reasoning was not the systematizations of general uniformities whereby one individual would be able to refer to an object in his experience which corresponds point to point with the object in another individual's experience, but the kind of laws of nature which could regulate a four-dimensional continuum where all natural forces are accounted for. If every individual, every monad is a center of perceptive activity coördinating from the standpoint of itself as absolute, the universe mirrored in it, then, as Stuart Mill said, the ultimate laws of nature would refer to the qualitative sensations of every monad, and their number would consequently be at least equal to the number of these sensations. But this view is quite the reverse of the actual method of physical science.

As Professor Planck remarked it, the characteristic of the evolutions of physics is, that it digresses more and more from what he calls "anthropomorphic considerations," that is to say, from the "ego" of the observer. In fact, when a professor delivers a series of lectures on physics, he never makes the slightest reference to the particular sensations and perceptions of the subject of the observations and experiments; on the contrary, every one of his affirmations conveys an unshaken faith in the existence of things independently of sense-perception. And it is a well-known fact in methodology, that a necessary condition of the exactness of experimental methods in the deduction of what is called "the personal equation observations and experiments. With reference to space and time,

these categories are to Einstein only convenient ways of fitting observed phenomena into a systematic theory, and the method of measurement is simply the comparison of two such phenomena. The consciousness of space and time is eliminated in conducting exact measurements; so that the measures of space and time are conditioned by the phenomena which they are used to describe. The human factor arises only in the suggestion and selection of the phenomena coördinated and in the suggestion of the qualitative distinction between space and time.

These considerations do not mean, however, that it is possible to describe nature when the mind is gone. The existence only and not the conception of nature exists independently of the mind. Existence as such is an absolute indefinable; because a definition gives only the essence of a thing, and not its existence, for otherwise, anything which we could think of would necessarily exist. What exists in its actual form is not the general, which is only fundamentalite in re, but the particular, which is infinitely diverse. And because the object of knowledge is always general in judgment, no fact ever is just that which it means, or can mean what it is; we never assert the fact in our head, but something else which that fact stands for. While that which is perceived by the senses is paralled out in a series of particular sensations, that which is conceived by the intellect takes the form of unity, of a general idea.

Although there is a fundamental duality between the process of thought and nature, there is, however, a certain conformity between our reason and the external world; not only because the mind itself is a part of Reality but also because it would be an imperfection in the plan of Creation if we were not adapted to the world in which we live in such a way as to make possible not only our material living, but also our intellectual development. The conformity of the order in nature and the order in mind, however, does not take the shape of a geometrical congruence, of a biunivocal point to point correspondence between mind and nature. The finitude of our intellect, the materialty of our means of knowing, hinder us from penetrating adequately the plan of the world. As knowledge requires the mind as one of its terms, we can understand the relations between things and the things themselves only in relation to our sensations and our intellect. We know the order in mind, because we are concerned here with possibilities, with formal truth alone; but the ultimate nature of things is an absolute limit towards which we draw

nearer and nearer asymtotically. And this Reality-Asymptote is not a mere appearance, a refracted image of a higher reality, but Reality itself. Science, therefore, does not give a perfect picture of the Universe; but it expresses true relations between real objects, as in every physical theory there is a certain invariant, which gives its value to science. That invariant, whatever be the nominalistic formalities with which we clothe it, is a part of the Reality-asymptote itself, a segment of it, the length of which increases every day. We do not create that invariant, we create only its expression.[2]

I am not in a position to give an estimate of the absolute distance between the actual point of our science-curve and its reality-asymptote because our knowledge is only a particle of that curve which is gradually generating as the world goes on. But even if our science is hopelessly condemned to keep at an insuperable distance from Reality, we must not lose courage in trying to further our knowledge. Because science has not only a static aim, to-wit, the contemplations of truth as such, but also a dynamic purpose, which is the embetterment and perfection of our material living as well as of our moral life.

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[2] Cf. my paper on *Geometry and Relativity*, read before the Aristotelian Society on June 12th, 1922 (in the *Proceedings*, 1922).